Lysack, W. 1982.

1981 Lake Winnipeg Fish Stock Assessment Program.

MANITOBA
DEPARTMENT OF NATURAL RESOURCES
Fisheries Branch

MS Report No. 82-28, 99pp.

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ERRATA

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Walt Lysack

Jan.3,1983

INTRODUCTION

This report presents the results of the third annual fish stock assessment program on Lake Winnipeg. This program was initiated in 1979 in response to a need for a standardized stock monitoring program so that year-to-year comparisons of population dynamics would be valid (Lysack 1980, 1981).

The objectives of this study were to:

1. estimate mortality rates of walleye, sauger and whitefish stocks
2. describe maturity regimes
3. describe growth regimes
4. compare mean total biomasses of fish caught in various meshes in the northern and southern basins of Lake Winnipeg.
5. determine age comparisons, mean ages and mortality rates of commercially caught walleyes, saugers and whitefish in the various management zones of Lake Winnipeg.
6. relate fish stock characteristics to commercial fishing activities in the northern and southern basins of Lake Winnipeg.

This study was restricted to the ice-free season on Lake Winnipeg. Only one or two gangs of gillnets were set for an overnight period at each sampling site.

METHODS AND MATERIALS

The methods employed in this study were identical to those described by Lysack (1980) with the following exceptions:

1. the 1981 experimental sampling period (May 27 - Sept. 25) began earlier and lasted longer than it did in previous years.
2. Since only two gangs were set in the channel area and since these gangs caught extremely few fish, the data collected from these gangs were combined with those from the gangs set in the southern basin (Fig. 1). Thus data from gangs 1 - 12 were considered representative of the southern basin while data from gangs 14 - 24 represented the northern basin.

Table 1 lists dates, locations and durations of experimental gillnet sets in 1981. Table 2 lists dates and locations of commercial samplings.

Not all whitefish from gangs 14 and 15 were sampled. In this case, the number of unsampled whitefish from a given mesh was multiplied by the mean weight of sampled whitefish from that mesh to obtain values for estimating mean biomass mesh^{-1}. In cases where a gang was set longer than one overnight period, mean biomass mesh^{-1} estimates were corrected for the number of days the gang was in the water.

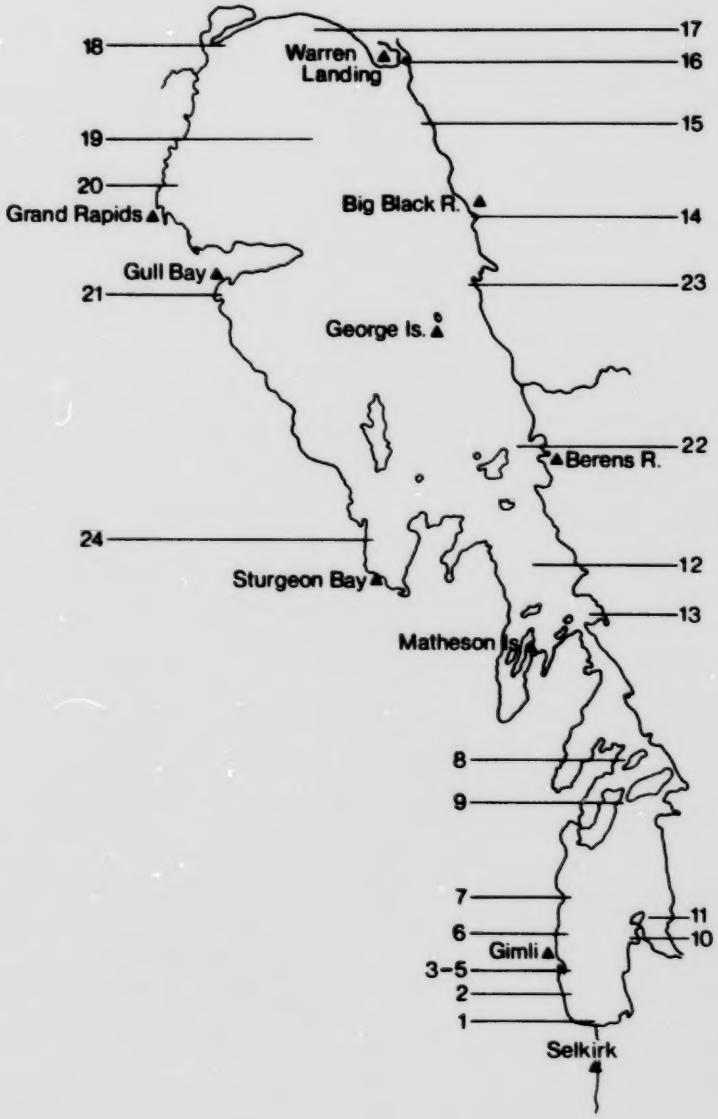


Fig. 1. Locations of sampling stations on Lake Winnipeg. Numbers denote chronological order of experimental gang sets. Triangles indicate locations of commercial packing facilities.

Table 1. 1981 experimental gang locations.

Gang no.	Location*	Date	Duration of set (days)
South basin			
1	Red River	May 27	1
2	Winnipeg Beach	May 28	1
3	Willow Point	June 2	1
4	Willow Point	June 3	1
5	Willow Point	June 19	3
6	Camp Morton	June 24	1
7	Arnes	June 26	1
8	Punk Island	July 7	1
9	Hecla Island	July 16	1
10	Victoria Beach	Sept. 16	1
11	Elk Island	Sept. 17	1
12	Dowling Reef	Sept. 22	1
13	Bloodvein Bay	Sept. 25	1
North basin			
14	Big Black River	July 6	1
15	Spider Islands	July 7	1
16	Warren's Landing	July 8	1
17	Mossy Ranges	July 9	1
18	Gaps	July 10	1
19	"Deep"	July 11	1
20	Grand Rapids	July 12	1
21	Gull Bay	July 13	1
22	Berens River	July 22	1
23	Poplar Reefs	July 23	1
24	Sturgeon Bay	July 28	1

* see Fig. 1.

Table 2. 1981 commercial sampling schedule.

Location*	Dates	Sampled species
Selkirk	June 8, 26, July 2	sauger
	Sept. 11, 29, Oct. 13	walleye
Gimli	June 9	walleye, sauger
	June 22, Oct. 15, 20	sauger
	Oct. 1	walleye
Matheson Island	June 10, Sept. 28	sauger
	June 24	whitefish
	June 25, Sept. 18, Oct. 7	walleye
Sturgeon Bay	June 11	walleye, whitefish
Berens River	June 16	walleye, whitefish
	Sept. 23	walleye
George Island	June 5	whitefish
Gull Bay	June 5	walleye
Big Black River	June 10	walleye, whitefish
Grand Rapids	June 6, Aug. 18	walleye, whitefish
Warren Landing	June 16	whitefish

* see Fig. 1.

RESULTS

Experimental sampling

Maturity regimes

Regression analyses of male, female and combined sexes maturity schedules of walleyes (Table 3), saugers (Table 4) and whitefish (Table 5) showed significant relationships of maturity and age in all cases except northern walleye males and whitefish females (Table 6). Instantaneous maturity rates from all combined sexes curves were always intermediate to their sex-specific counterparts (Figs. 2-6). Abrasov's mean age of maturity was consistently higher than the mean age of maturity interpolated from all maturity curves (Table 6).

Southern walleye females and combined sexes matured faster than northern walleye females and combined sexes ($F = 30.11$, 1 and 5 d.f. and $F = 19.07$, 1 and 8 d.f., respectively). The elevations of the southern walleye female and walleye combined sexes maturity curves were significantly different from their northern counterparts ($F = 17.33$, 1 and 6 d.f. and $F = 48.66$, 1 and 9 d.f., respectively).

Southern sauger females and combined sexes matured faster than their northern counterparts ($F = 28.59$, 1 and 7 d.f. and $F = 17.47$, 1 and 8 d.f., respectively) although the elevations of northern and southern female and combined sexes maturity curves were not significantly different ($F = 0.03$, 1 and 8 d.f. and $F = 0.0005$, 1 and 9 d.f., respectively).

Table 3. Maturity schedules of northern and southern walleye stocks.

Area	Age (years)	No. immature fish			No. mature fish			% mature		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
North	1		1	1				0	0	0
	2		4	4				0	0	0
	3	1	6	7				0	0	0
	4	26	28	54	3	1	4	10.3	3.4	6.9
	5	39	87	126	4	12	16	9.3	12.1	11.3
	6	21	62	83	9	30	39	30.0	32.6	32.0
	7	15	22	37	3	14	17	16.7	38.9	31.5
	8	11	8	19	1	12	13	8.3	60.0	40.6
	9	2		2		4	4	0	100.0	66.7
		0.53 males: 1 female			0.27 males: 1 female			0.46 males: 1 female		
South	2	2	8	10	1	0	1	33.3	0	9.1
	3	65	112	177	28	0	28	30.1	0	13.7
	4	5	31	36	14	3	17	73.7	8.8	32.1
	5	8	34	42	67	16	83	89.3	32.0	66.4
	6	1	1	2	16	5	21	94.1	83.3	91.3
	7	2	1	3	32	24	56	94.1	96.0	94.9
	8				1	4	5			100.0
	9	0.44 males: 1 female			1	4	5	1 male: 1 female		
					2.86 males: 1 female					

Table 4. Maturity schedules of northern and southern sauger stocks.

Area	Age (years)	No. immature fish			No. mature fish			% mature		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
North	1	0	1	1	0	0	0	0	0	0
	2	2	2	4	0	0	0	0	0	0
	3	8	9	17	5	3	8	38.5	25.0	32.0
	4	20	17	37	25	10	35	55.6	37.0	48.6
	5	19	24	43	79	62	141	80.6	72.1	76.6
	6	12	19	31	125	102	227	91.2	84.3	88.0
	7	2	6	8	74	58	132	97.4	90.1	94.3
	8	2	3	5	57	38	95	96.6	92.7	95.0
	9	1	1	2	12	23	35	92.3	95.8	94.6
	10				6	1	7			
	11	0.80 males: 1 female			1	1	2	1.18 males: 1 female		
	12					1	1			
	13					1	1			
					1.28 males: 1 female					
South	1	2	3	5	0	0	0	0	0	0
	2	35	39	74	6	0	6	14.6	0	7.5
	3	62	80	142	29	2	31	31.9	2.4	17.9
	4	24	26	50	38	13	51	61.3	33.3	50.5
	5	50	40	90	166	60	226	76.9	60.0	71.5
	6	30	22	52	330	145	475	91.7	86.8	90.1
	7	11	2	13	220	76	296	95.2	97.4	95.8
	8				39	15	54	100.0	100.0	100.0
	9				6	0	6			
	10	1.01 males: 1 female			1	0	1	2.01 males: 1 female		
					2.68 males: 1 female					

Table 5. Maturity schedules of northern whitefish stocks.

Age (years)	No. immature fish			No. mature fish			% mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
2	11	13	24	0	0	0	0	0	0
3	234	222	456	15	11	26	6.0	4.7	5.4
4	240	227	467	168	196	364	41.2	46.3	43.8
5	218	180	398	270	398	668	55.3	68.9	62.7
6	126	80	206	133	191	324	51.4	70.5	61.1
7	18	12	30	22	41	63	55.0	77.4	67.7
8	1	0	1	5	8	13	83.3	100	92.9
9				0	0	0			100.0
10	1.15 males: 1 female				1	1	0.92 males: 1 female		
				0.72 males: 1 female					

Table 6. 1981 maturity curves of Lake Winnipeg walleyes, saugers and whitefish.

Species	Area	Type	Maturity curve $-\log_e \frac{k-y}{y} = a + b \cdot age$	Correlation coefficient	Age at 50% mature (years)	Abrasov's mean age of maturity (years)	Test F ratio and d.f.
Walleye	North	Male	Y = -3.430 + .310X	.612	11.06	8.25	1.20(1,2)*
		Female	Y = -6.642 + .904X	.975	7.34	7.53	58.75(1,3)
		Combined	Y = -4.973 + .614X	.968	8.09	8.11	58.57(1,4)
	South	Male	Y = -3.080 + .989X	.962	3.11	3.85	36.92(1,3)
		Female	Y = -9.977 + 1.891X	.997	5.28	5.80	291.49(1,2)
		Combined	Y = -4.982 + 1.147X	.987	4.34	4.93	156.28(1,4)
Sauger	North	Male	Y = -3.720 + 1.030X	.996	3.61	4.48	355.90(1,3)
		Female	Y = -3.309 + .776X	.977	4.26	5.03	82.52(1,4)
		Combined	Y = -3.029 + .797X	.983	3.80	4.71	111.80(1,4)
	South	Male	Y = -3.616 + .971X	.996	3.72	4.28	531.63(1,4)
		Female	Y = -8.315 + 1.724X	.985	4.82	5.20	100.24(1,3)
		Combined	Y = -4.807 + 1.151X	.998	4.18	4.67	873.26(1,4)
Whitefish	North	Male	Y = -3.834 + .666X	.873	5.76	6.08	12.76(1,4)
		Female	Y = -4.802 + .950X	.868	5.05	5.32	9.19(1,3)*
		Combined	Y = -4.531 + .859X	.908	5.27	5.66	18.82(1,4)

* non-significant at P = 0.05

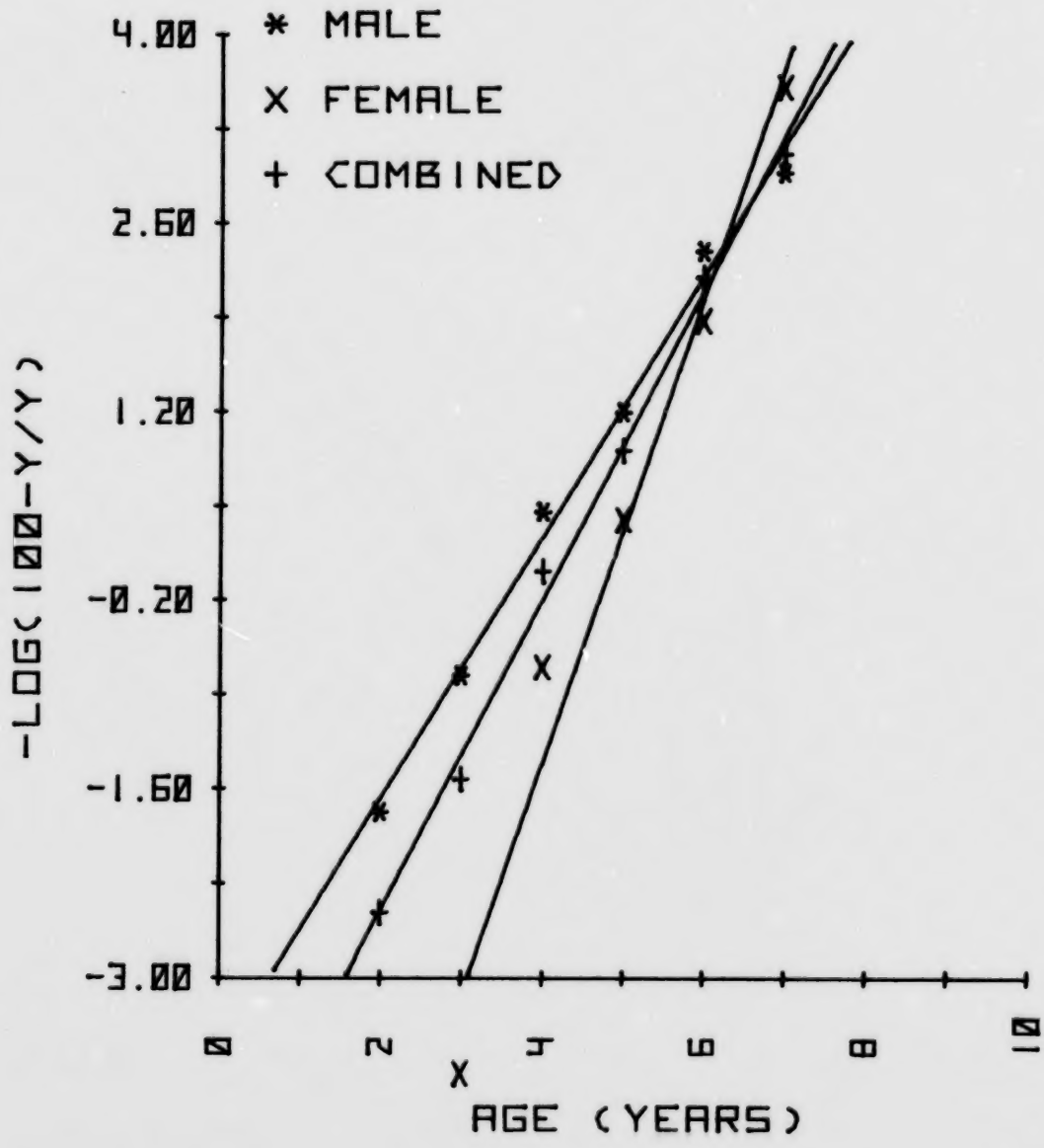


Fig. 2. Maturity curves of southern Lake Winnipeg saugers.

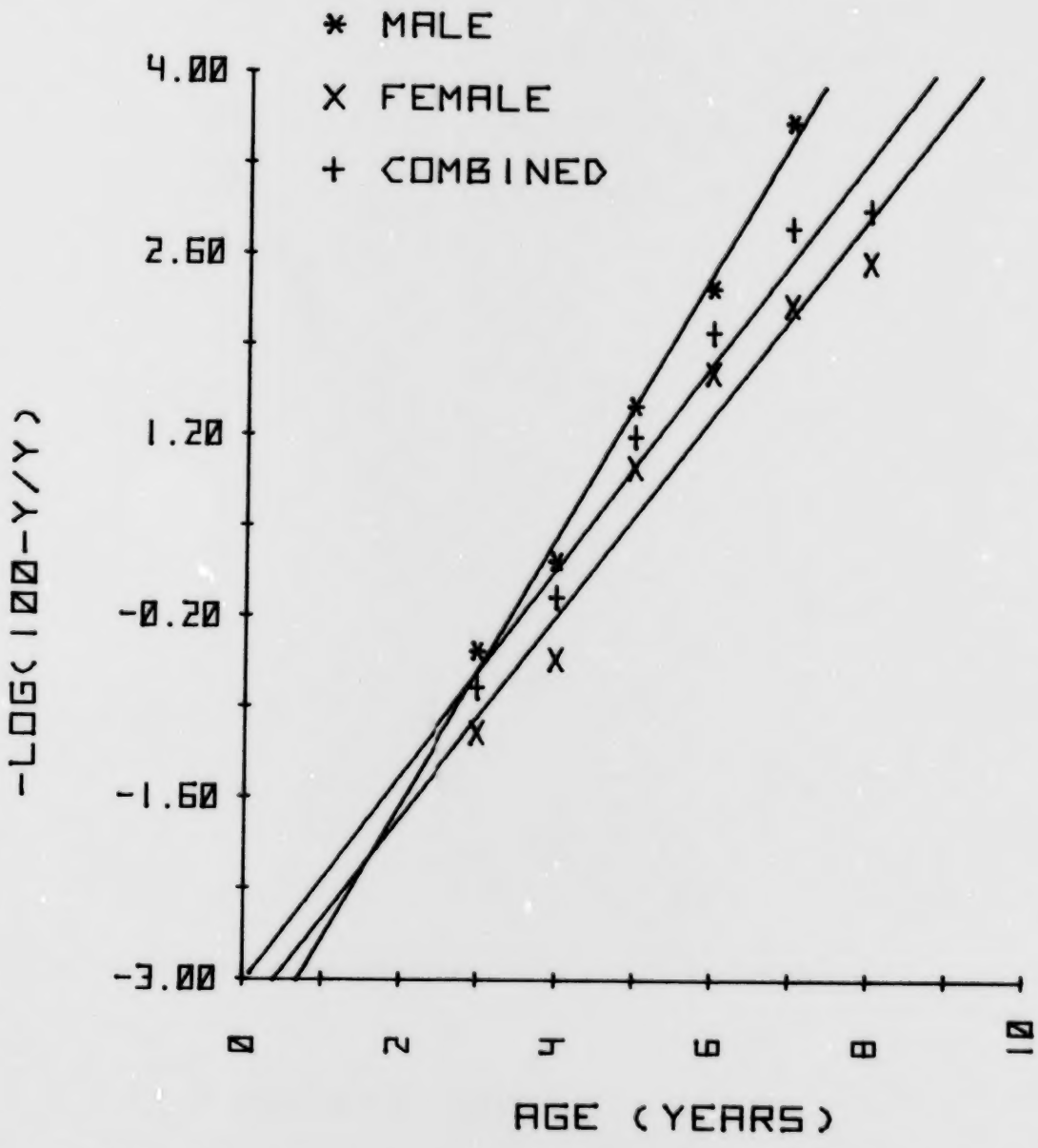


Fig. 3. Maturity curves of northern Lake Winnipeg saugers.

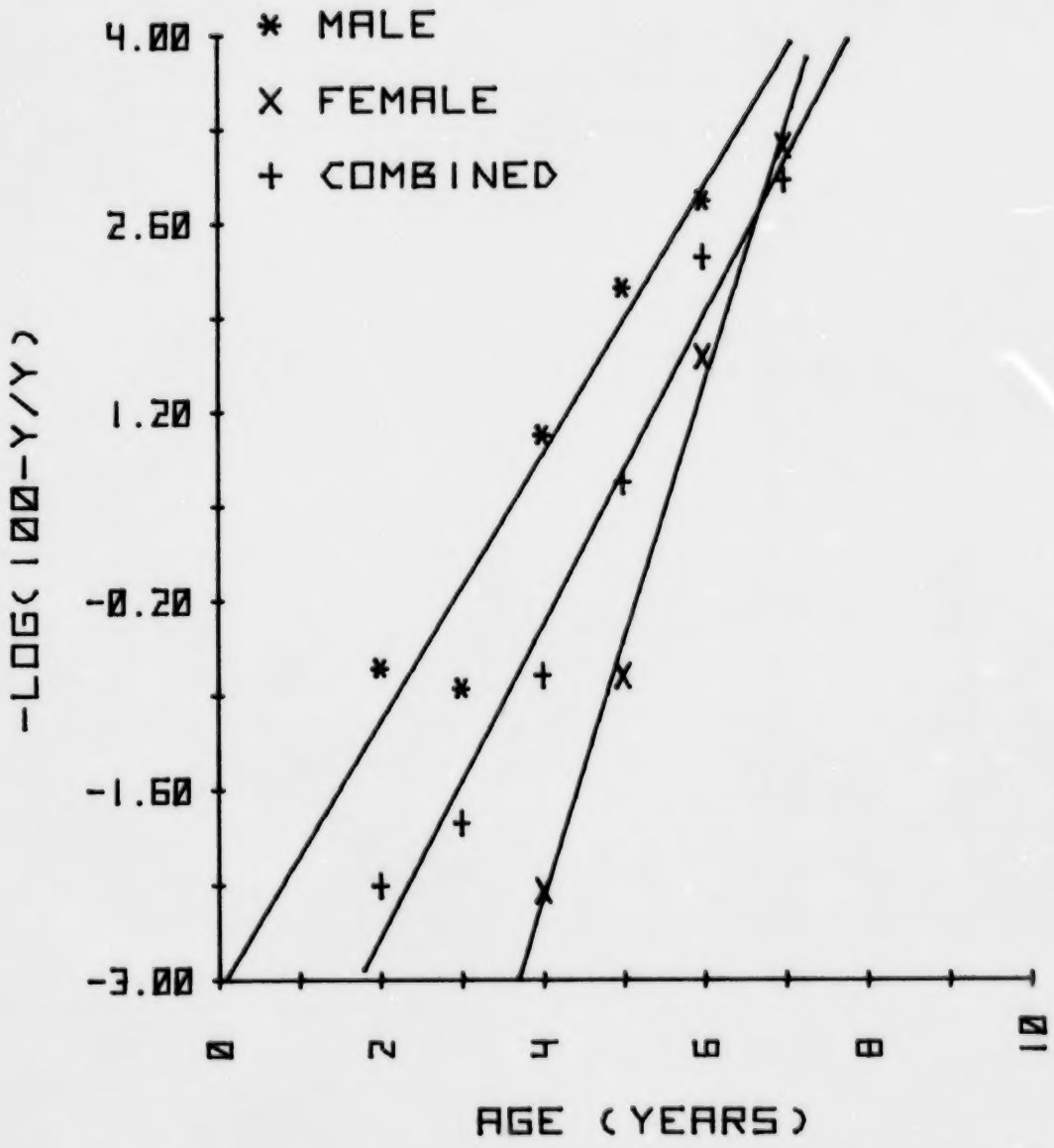


Fig. 4. Maturity curves of southern Lake Winnipeg walleyes.

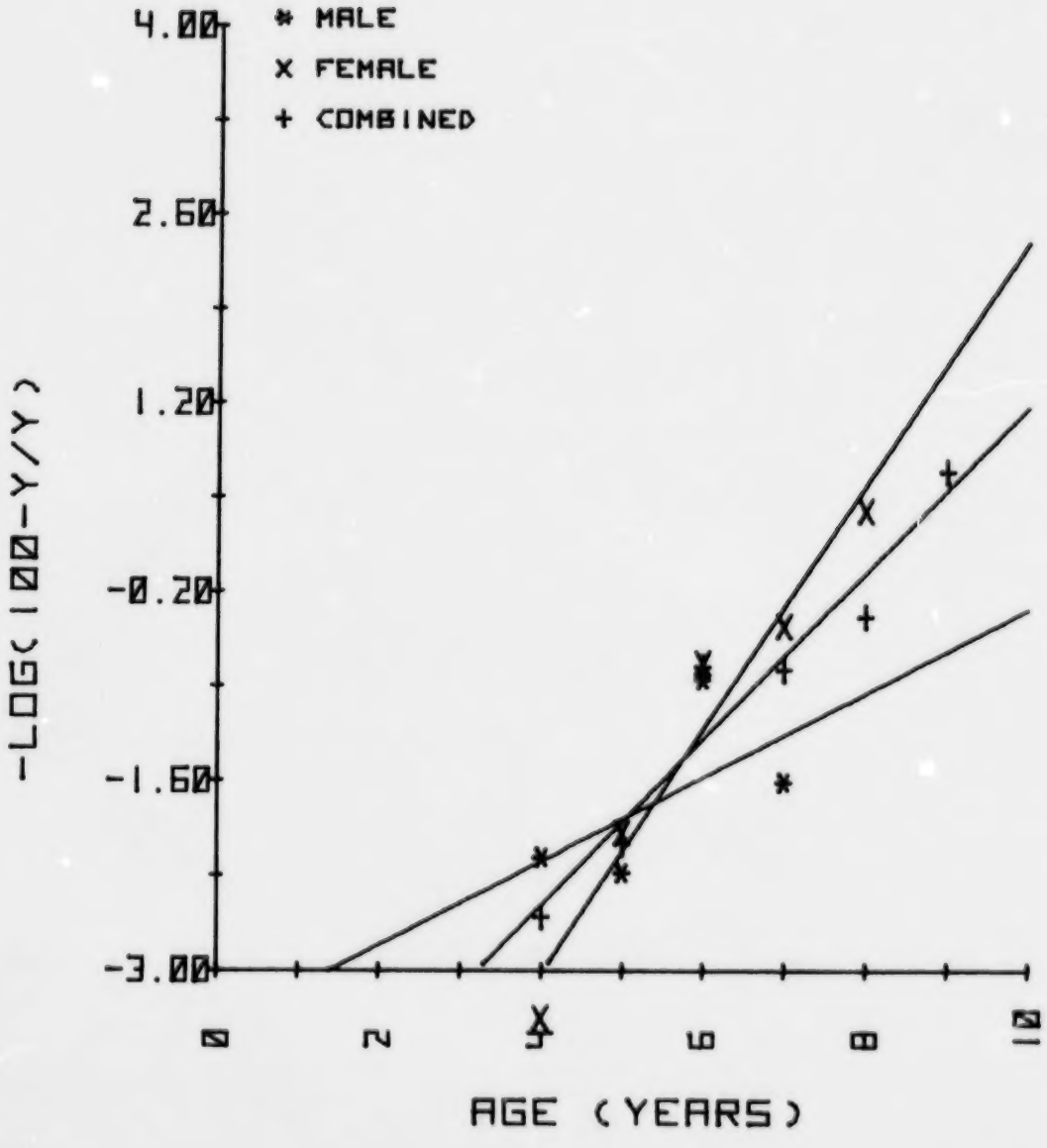


Fig. 5. Maturity curves of northern Lake Winnipeg walleyes.

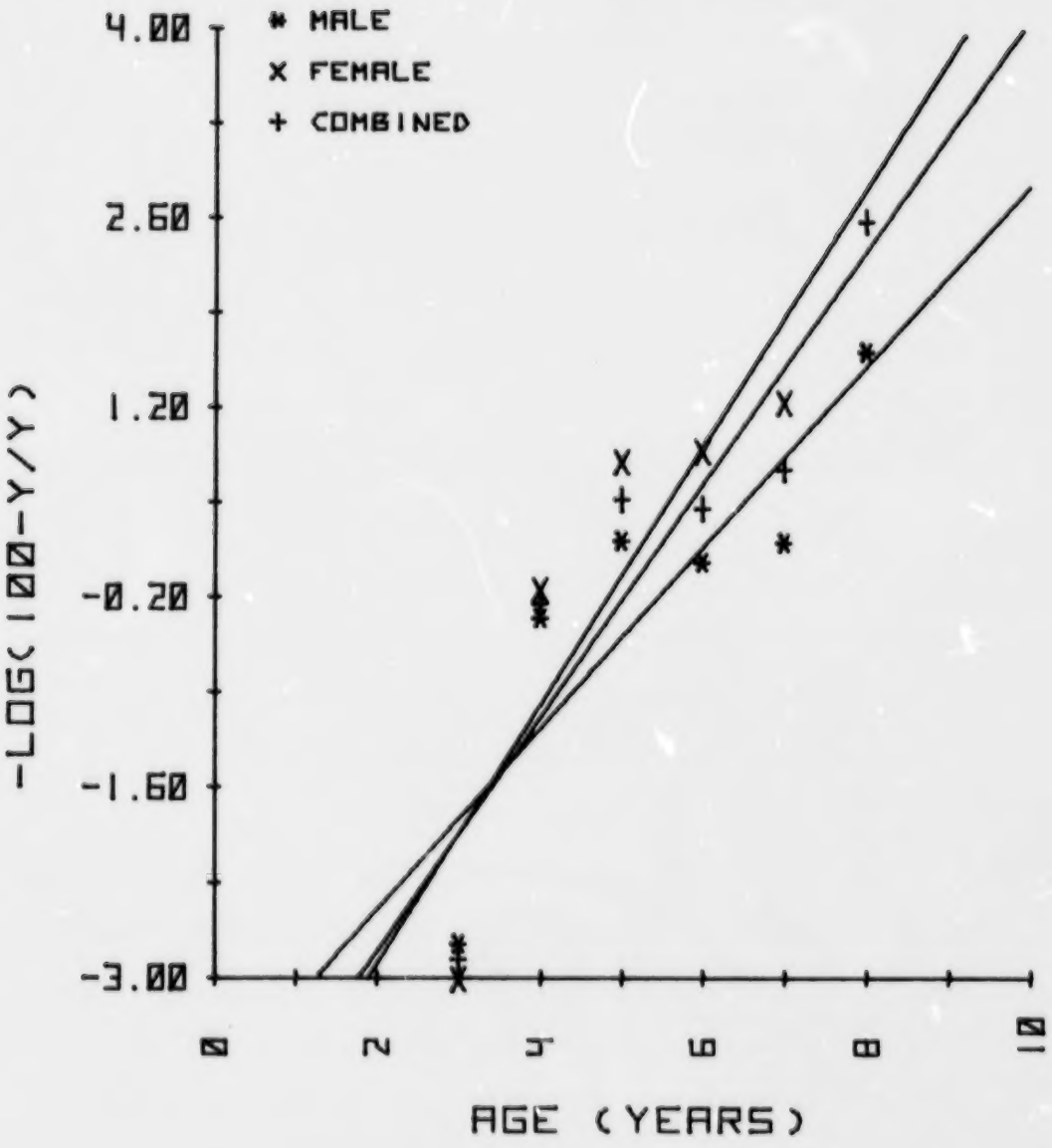


Fig. 6. Maturity curves of northern Lake Winnipeg whitefish.

Differences among age-specific mean lengths of immature and mature male and female walleyes (Fig. 7), saugers (Fig. 8) and whitefish (Fig. 9) indicate that the maturation process is more size specific than age-specific. The male:female sex ratios of walleyes and saugers were lower in the north basin than in the south basin (Table 3, 4).

Growth regimes

Age-specific mean lengths and mean weights of saugers (Table 7), walleyes (Table 8) and whitefish (Table 9) from northern and southern Lake Winnipeg were used to derive length-weight relationship (Table 10). The slope of the northern sauger length-weight curve was not significantly different from that of southern saugers ($F = 0.81$, d.f. = 1, 19). The elevation of the southern sauger length-weight curve was significantly higher than that of northern saugers ($F = 5.52$, d.f. = 1, 20) (Fig. 10). Differences between slopes and between elevations of northern and southern walleye length-weight curves were non-significant (slopes $F = 4.51$, d.f. = 1, 13; elevations $F = 2.23$ d.f. = 1, 14) (Fig. 11).

Walford plots for saugers, walleyes and whitefish showed significant relationships of L_{t+1} and L_t in all cases (Table 11, Figs. 12-16). The asymptotic sizes of walleyes and saugers estimated by Walford plots approached observed maximum sizes when age classes containing relatively few (< 5) fish were deleted from analyses. Walleyes and saugers attained larger sizes in the north basin than in the south basin.

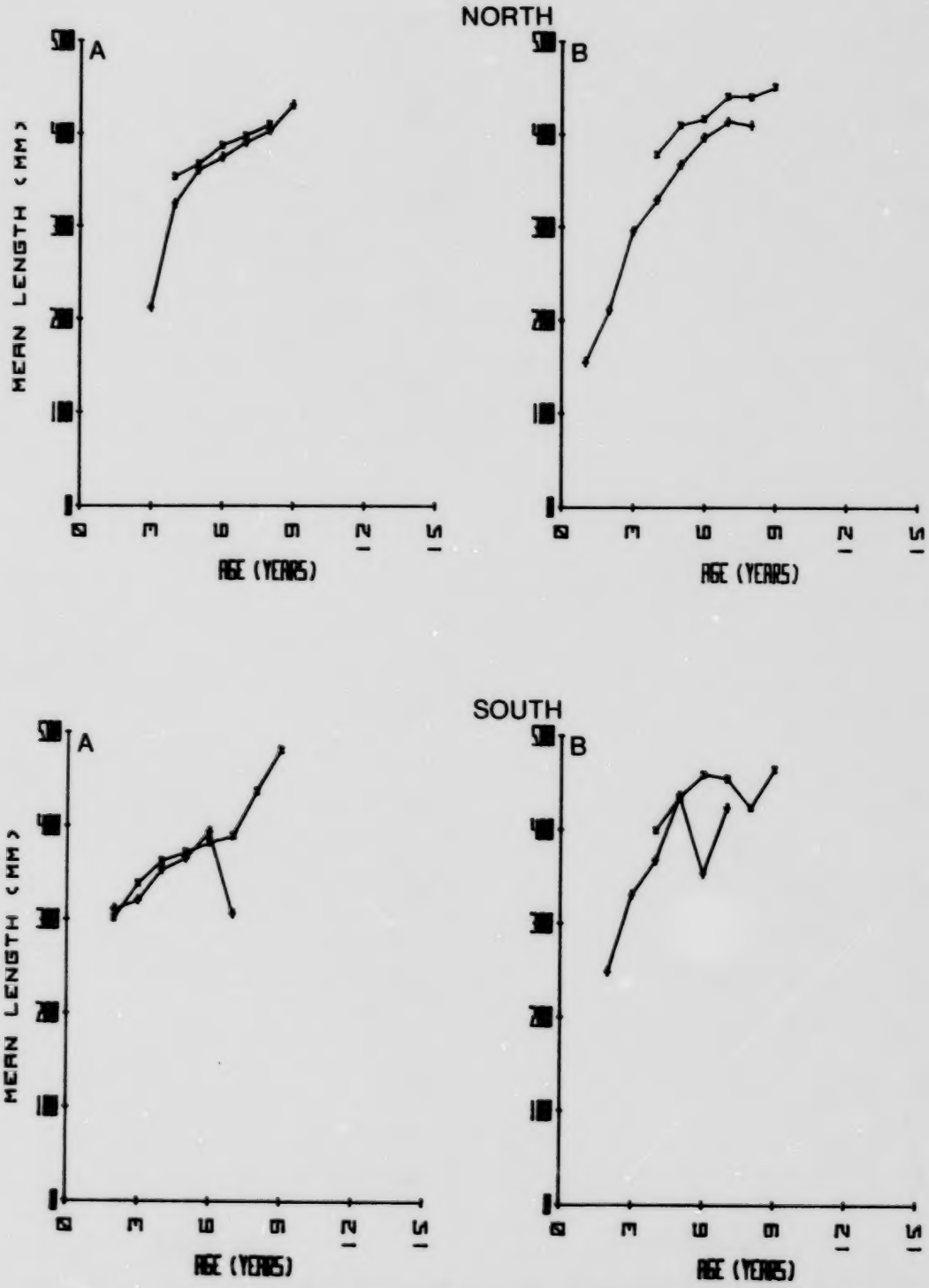


Fig. 7. Growth of immature (+) and mature (X) male (A) and female (B) walleyes from northern and southern Lake Winnipeg.

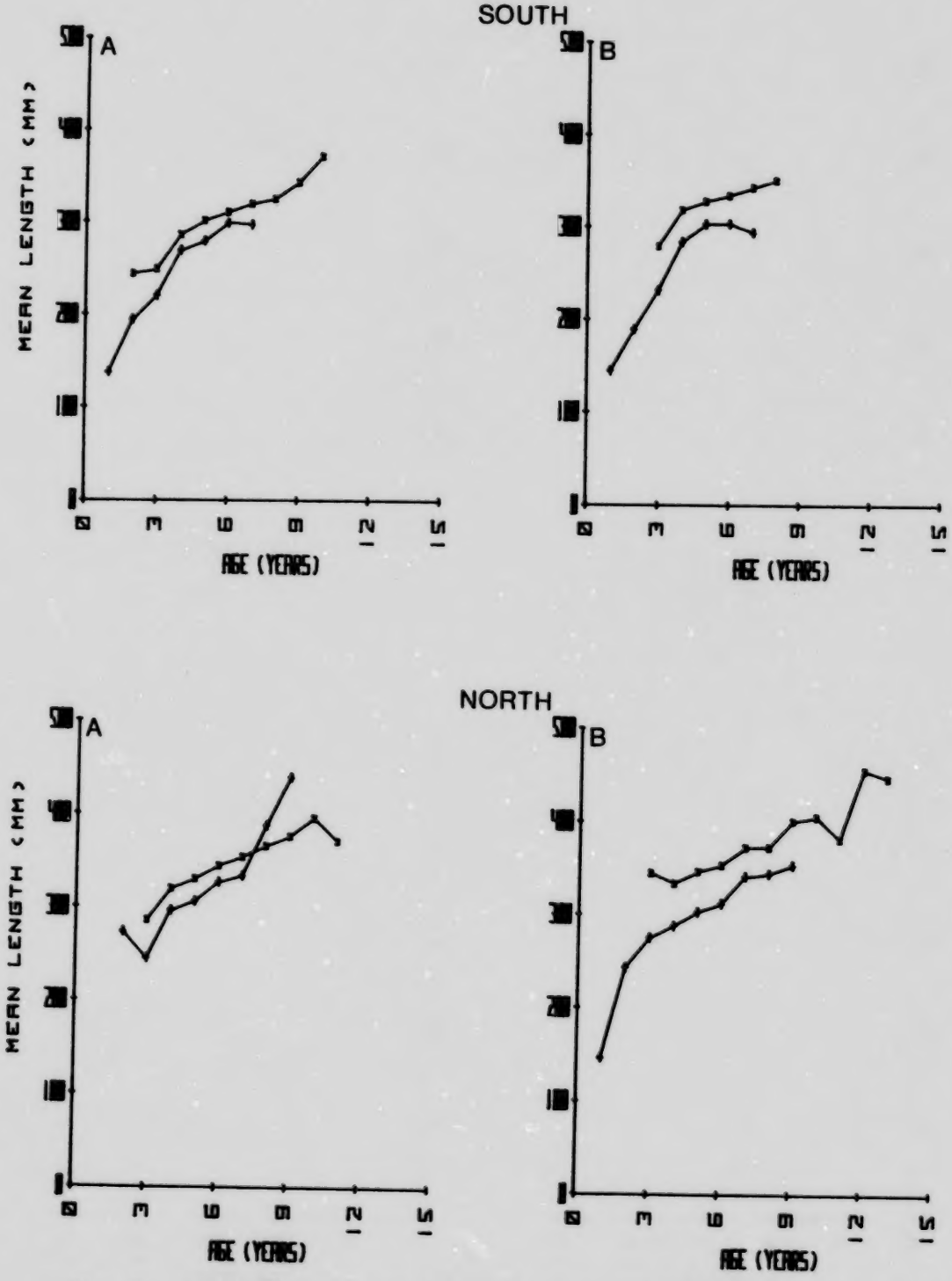


Fig. 8. Growth of immature (+) and mature (X) male (A) and female (B) saugers from northern and southern Lake Winnipeg.

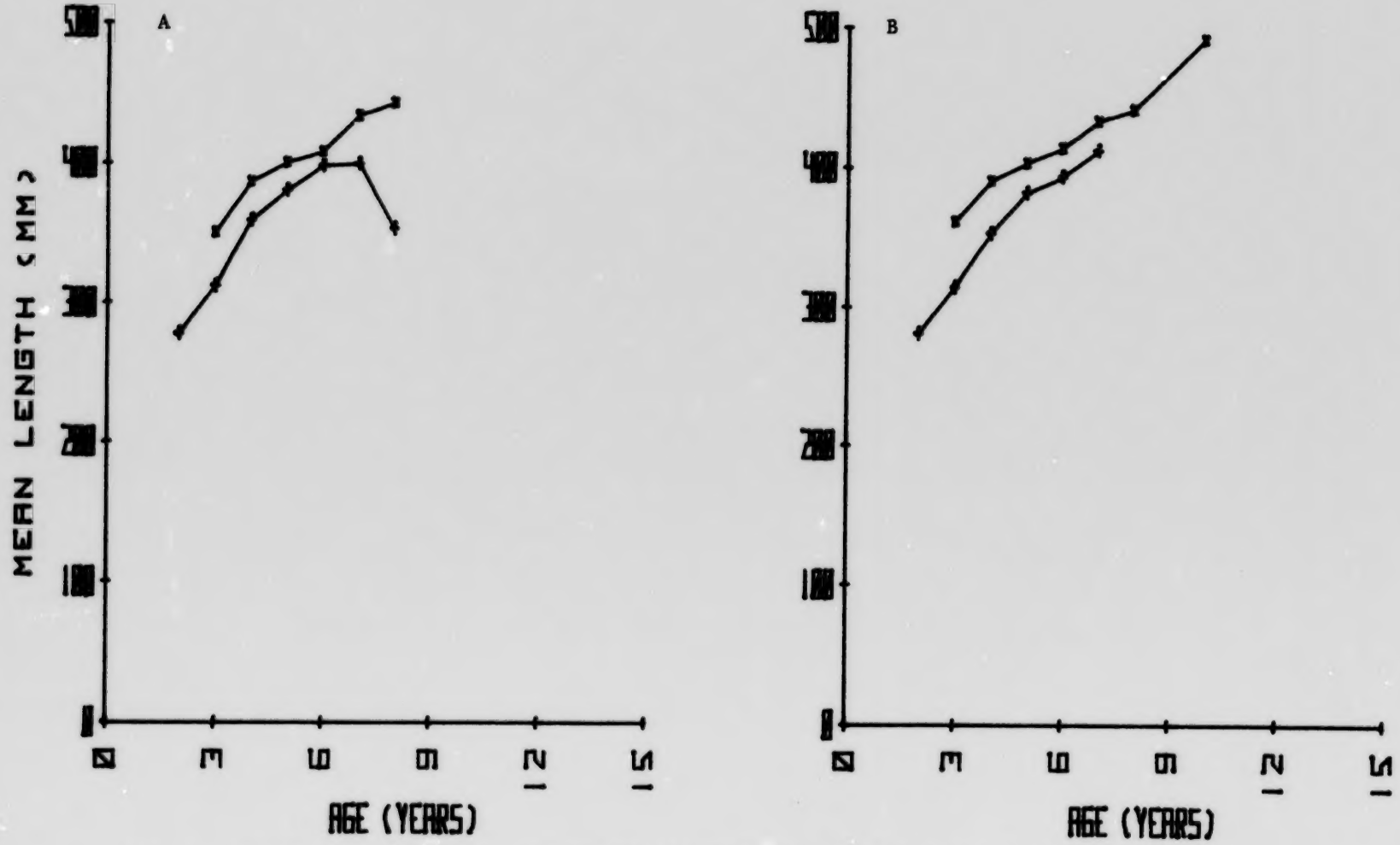


Fig. 9. Growth of immature (+) and mature (X) male (A) and female (B) whitefish.

Table 7. Age-specific mean fork lengths and mean weights of saugers from the northern and southern basins of Lake Winnipeg, 1981.

Area	Age (years)	No. fish	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
North	1	1	146.00	-	30.00	-
	2	4	258.00	13.29	157.50	19.31
	3	25	275.76	8.50	222.40	21.55
	4	72	307.50	5.29	321.22	16.34
	5	184	329.77	2.58	385.22	10.21
	6	258	345.02	2.06	443.26	9.23
	7	140	361.20	2.83	535.71	15.82
	8	100	368.58	3.21	570.90	18.92
	9	37	393.14	6.17	696.76	34.72
	10	7	398.00	6.59	748.57	35.82
	11	2	377.00	5.00	660.00	40.00
	12	1	456.00	-	850.00	-
	13	1	448.00	-	1040.00	-
South	1	6	139.67	5.55	30.00	4.47
	2	117	186.91	2.94	77.52	4.03
	3	191	227.14	2.03	130.62	4.00
	4	101	285.54	2.68	255.25	7.84
	5	316	303.21	1.42	302.31	4.80
	6	527	316.36	1.11	357.91	4.16
	7	309	324.58	1.42	400.74	6.02
	8	54	332.41	3.53	440.00	18.08
	9	6	343.33	16.30	500.00	92.99
	10	1	372.00	-	590.00	-

Table 8. Age-specific mean fork lengths and mean weights of walleyes from the northern and southern basins of Lake Winnipeg, 1981.

Area	Age (years)	No. fish	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
North	1	1	156.00	-	30.00	-
	2	4	212.00	12.83	102.50	22.87
	3	7	284.86	18.18	280.00	57.65
	4	58	329.66	4.90	408.10	17.10
	5	142	370.01	2.48	565.07	11.09
	6	122	398.28	2.88	722.87	14.92
	7	54	414.44	5.01	811.48	31.79
	8	32	419.88	5.71	858.13	37.57
	9	6	445.67	12.87	985.00	82.17
South	2	12	268.50	17.69	261.67	41.30
	3	205	328.86	1.60	402.83	6.33
	4	53	367.09	5.09	561.96	26.00
	5	125	397.54	4.01	734.68	23.74
	6	23	398.78	12.88	757.17	88.13
	7	59	414.20	7.13	845.59	41.75
	8	5	427.20	34.78	1022.00	202.96
	9	5	468.80	17.85	1218.00	128.43

Table 9. Age-specific mean fork lengths and mean weights of whitefish from the northern basin of Lake Winnipeg, 1981.

Age (years)	No. fish	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
2	24	279.50	4.31	314.58	14.36
3	482	315.58	1.54	457.78	6.54
4	831	370.74	1.11	762.01	6.96
5	1066	394.82	.78	913.72	5.57
6	530	406.31	1.05	1001.42	8.40
7	93	424.82	3.69	1162.04	32.33
8	14	436.29	11.90	1377.14	125.48
9	0	-	-	-	-
10	1	492.00	-	1500.00	-

Table 10. Age-specific mean length-weight curves of walleyes, saugers and whitefish from Lake Winnipeg, 1981.

Species	Area	Log_e mean weight = a + b · log_e mean length	Correlation coefficient	Test F ratio and d.f.
Walleye	North	Y = -12.979 + 3.269X	0.998	1472.46(1,7)
	South	Y = -10.599 + 2.878X	0.993	406.48(1,6)
Sauger	North	Y = -12.262 + 3.142X	0.996	1235.25(1,11)
	South	Y = -11.623 + 3.044X	0.999	4274.94(1,8)
Whitefish	North	Y = -11.553 + 3.072X	1.000	3253.58(1,3)

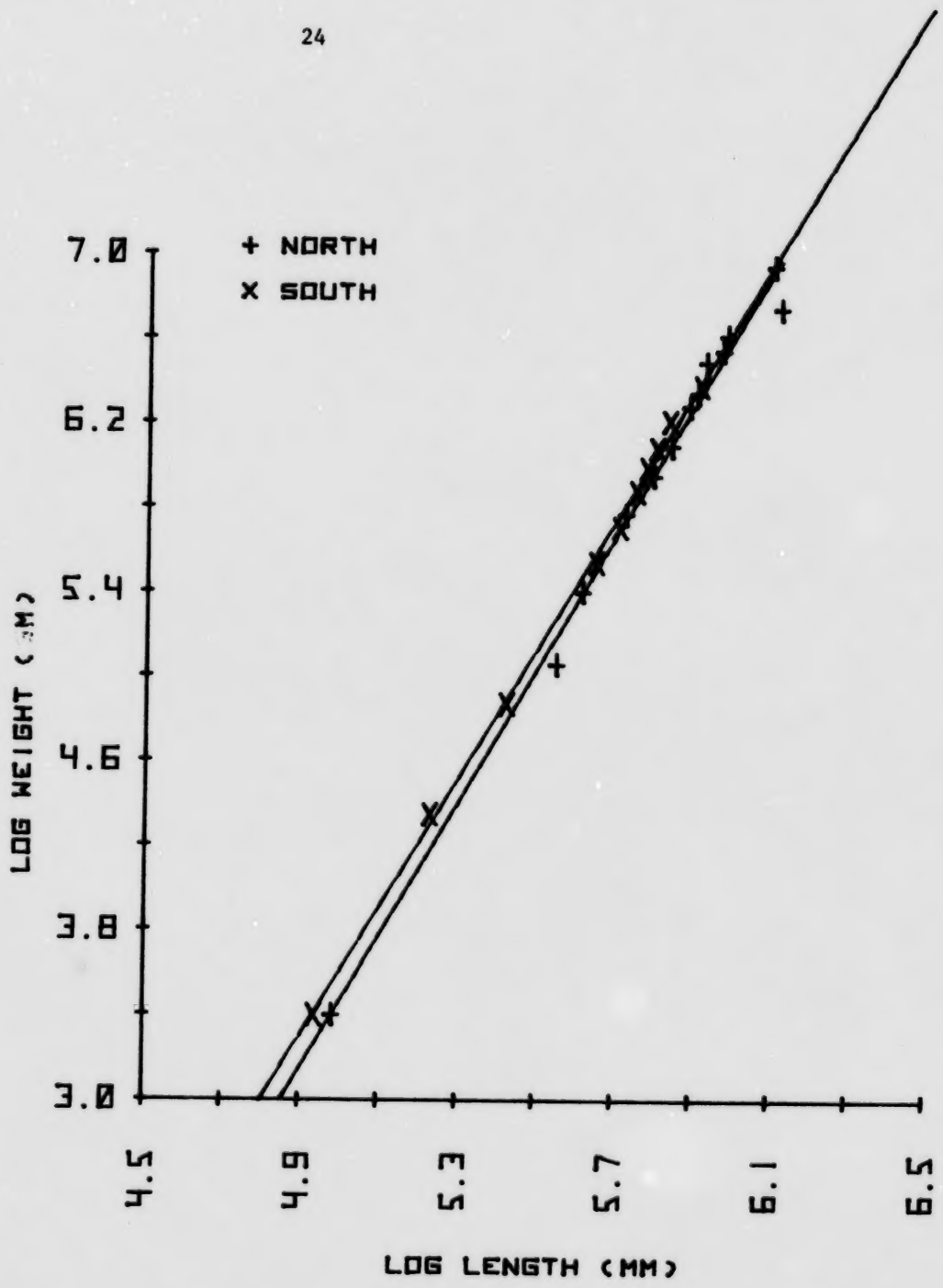


Fig. 10. Age-specific mean length-weight curves of saugers from northern and southern Lake Winnipeg.

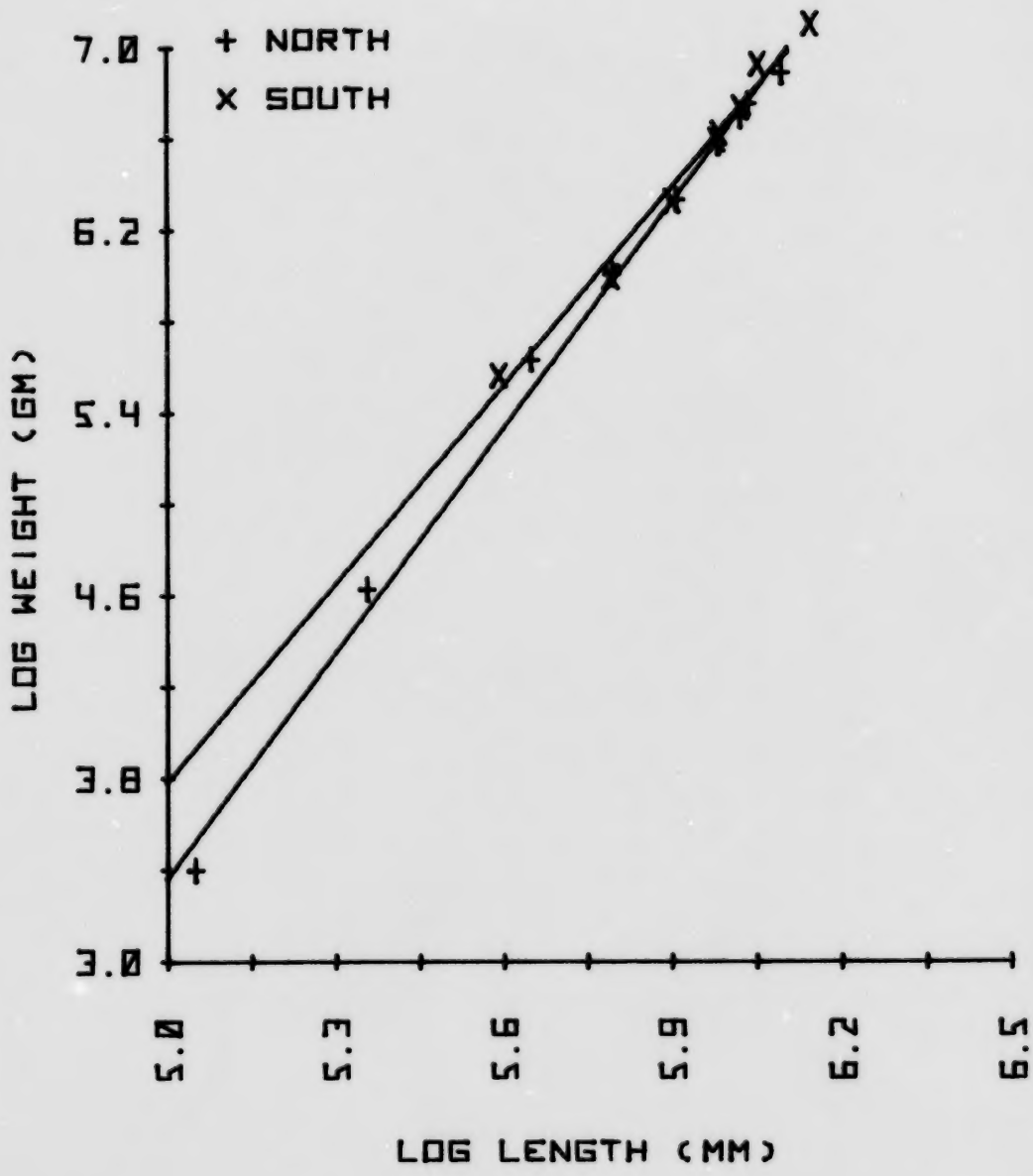


Fig. 11. Age-specific mean length-weight curves of walleyes from northern and southern Lake Winnipeg.

Table 11. Walford plots of whitefish and northern and southern Lake Winnipeg walleye and sauger stocks.

Species	Area	Walford equation $L_{t+1} = a \cdot b \cdot L_t$	L_∞ (mm)	Ages deleted	Correlation coefficient	Test F ratio and d.f.
Whitefish	North	Y = 69.71 + .895X	663.89	-	.945	41.45(1,5)
		Y = 115.98 + .754X	471.48	8-10	.975	77.60(1,4)
Walleye	North	Y = 100.42 + .801X	504.60	-	.992	377.11(1,6)
		Y = 104.47 + .784X	483.68	8,9	.992	298.87(1,5)
		Y = 137.28 + .694X	448.63	1-2,8-9	.997	643.25(1,4)
	South	Y = 121.66 + .750X	486.64	-	.945	41.85(1,5)
		Y = 158.63 + .635X	434.59	8,9	.982	111.03(1,4)
Sauger	North	Y = 130.40 + .686X	415.28	-	.903	44.26(1,10)
		Y = 38.18 + .950X	763.58	1-2,9-10,12-13	.864	20.67(1,7)
		Y = 64.43 + .868X	488.10	1-2, 9-10	.895	32.39(1,8)
	South	Y = 81.62 + .796X	400.12	-	.980	167.92(1,7)
		Y = 78.02 + .788X	368.00	3-4, 9-10	.999	4118.43(1,5)

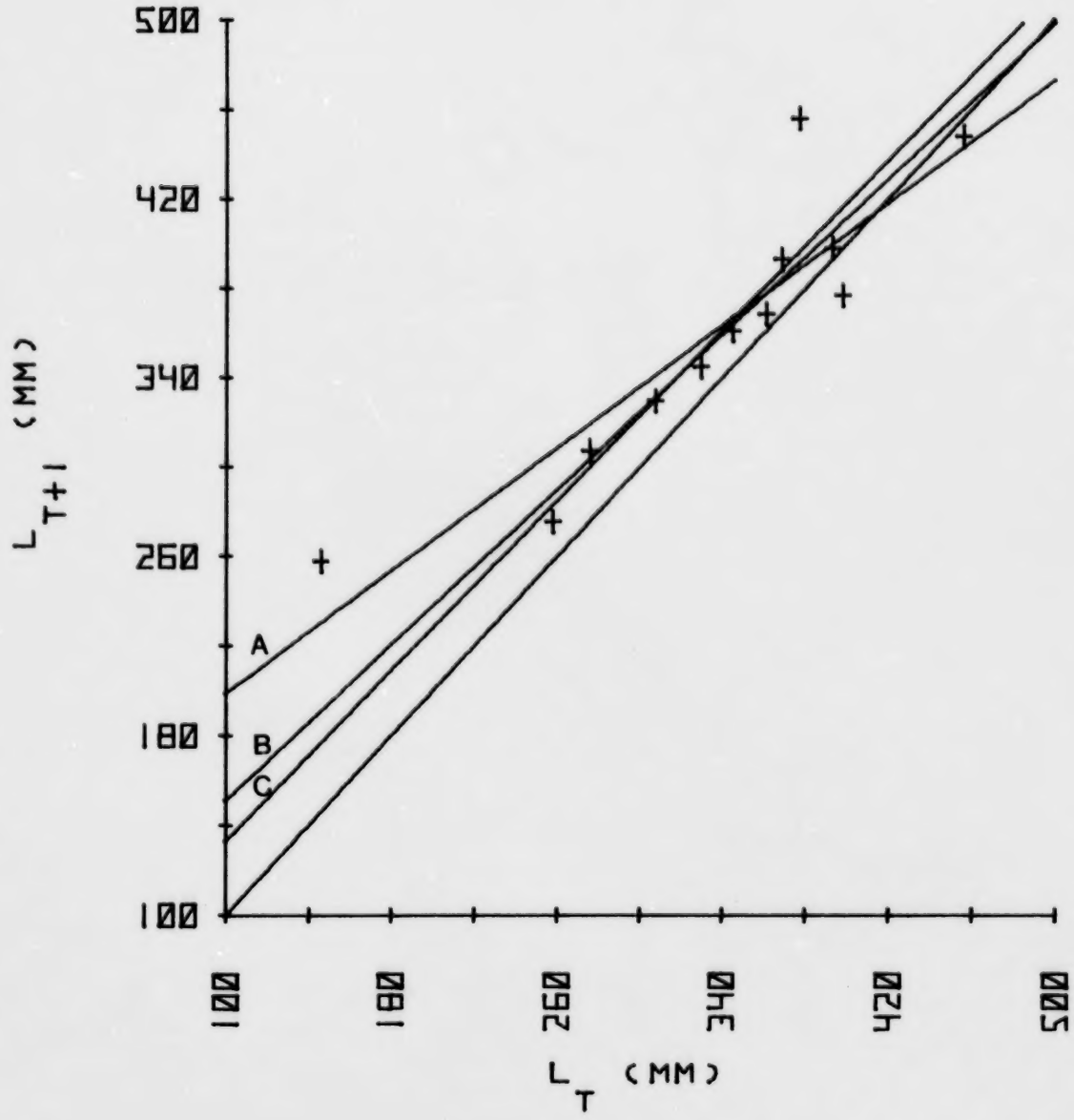


Fig. 12. Walford plots of northern sauger mean lengths. Curve A - all lengths, curve B - deleting lengths at ages 1-2 and 9-10, curve C - deleting lengths at ages 1-2, 9-10, 12-13.

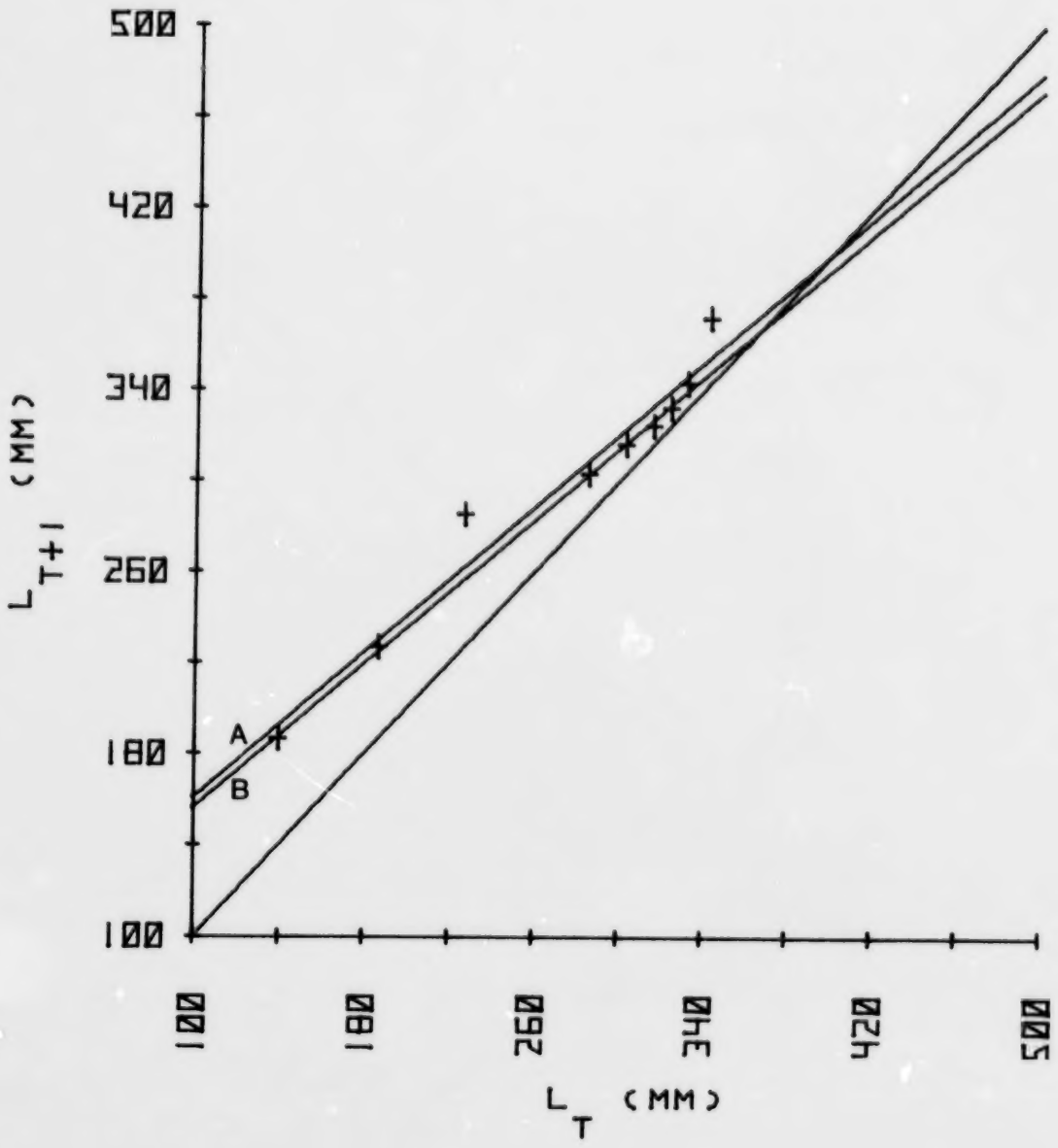


Fig. 13. Walford plots of southern sauger mean lengths. Curve A - all lengths, curve B - deleting mean lengths at ages 3-4, 9-10.

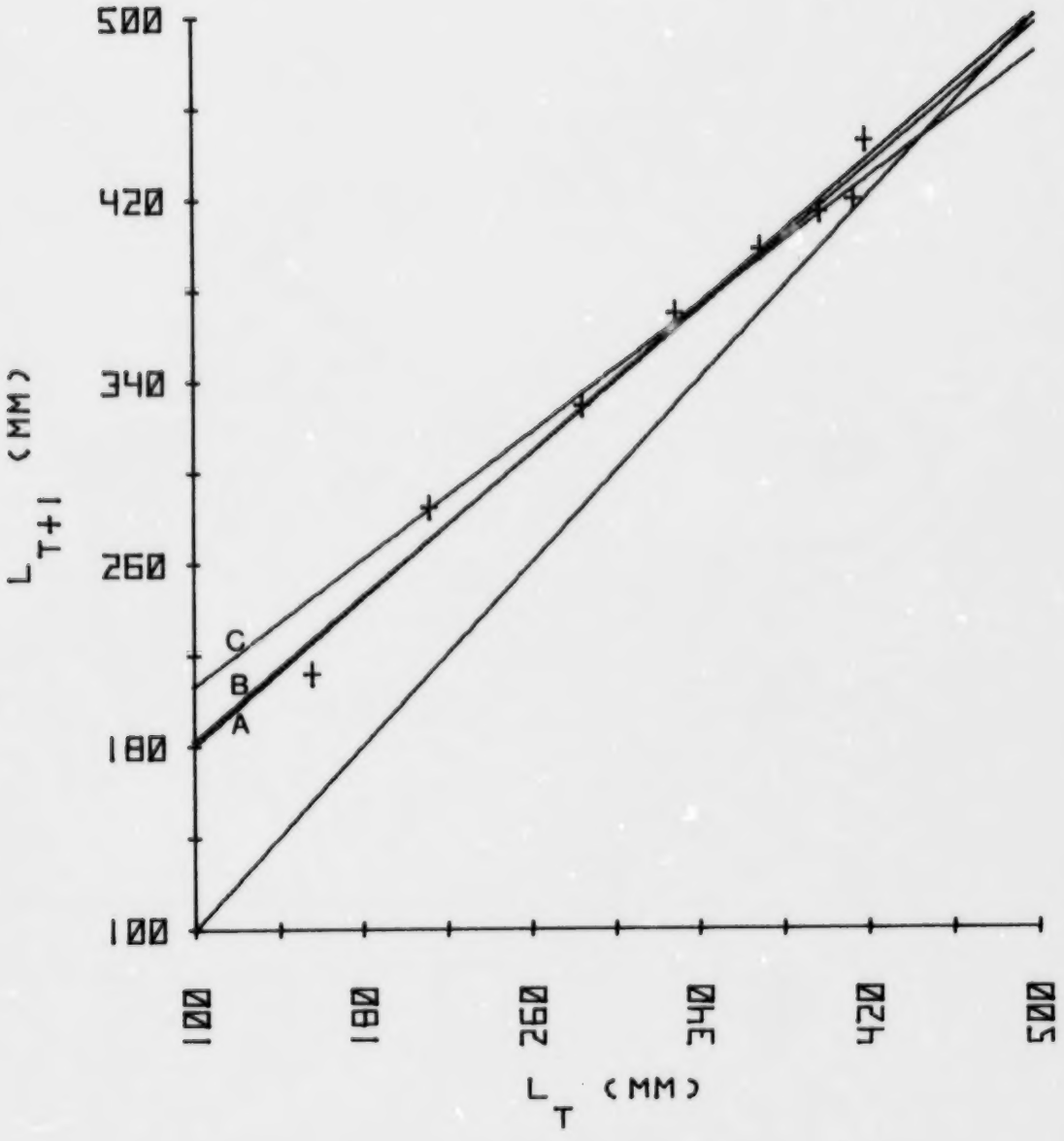


Fig. 14. Walford plots for northern walleye mean lengths. Curve A - all lengths, curve B - deleting mean lengths at ages 8-9, curve C - deleting mean lengths at ages 1-2, 8-9.

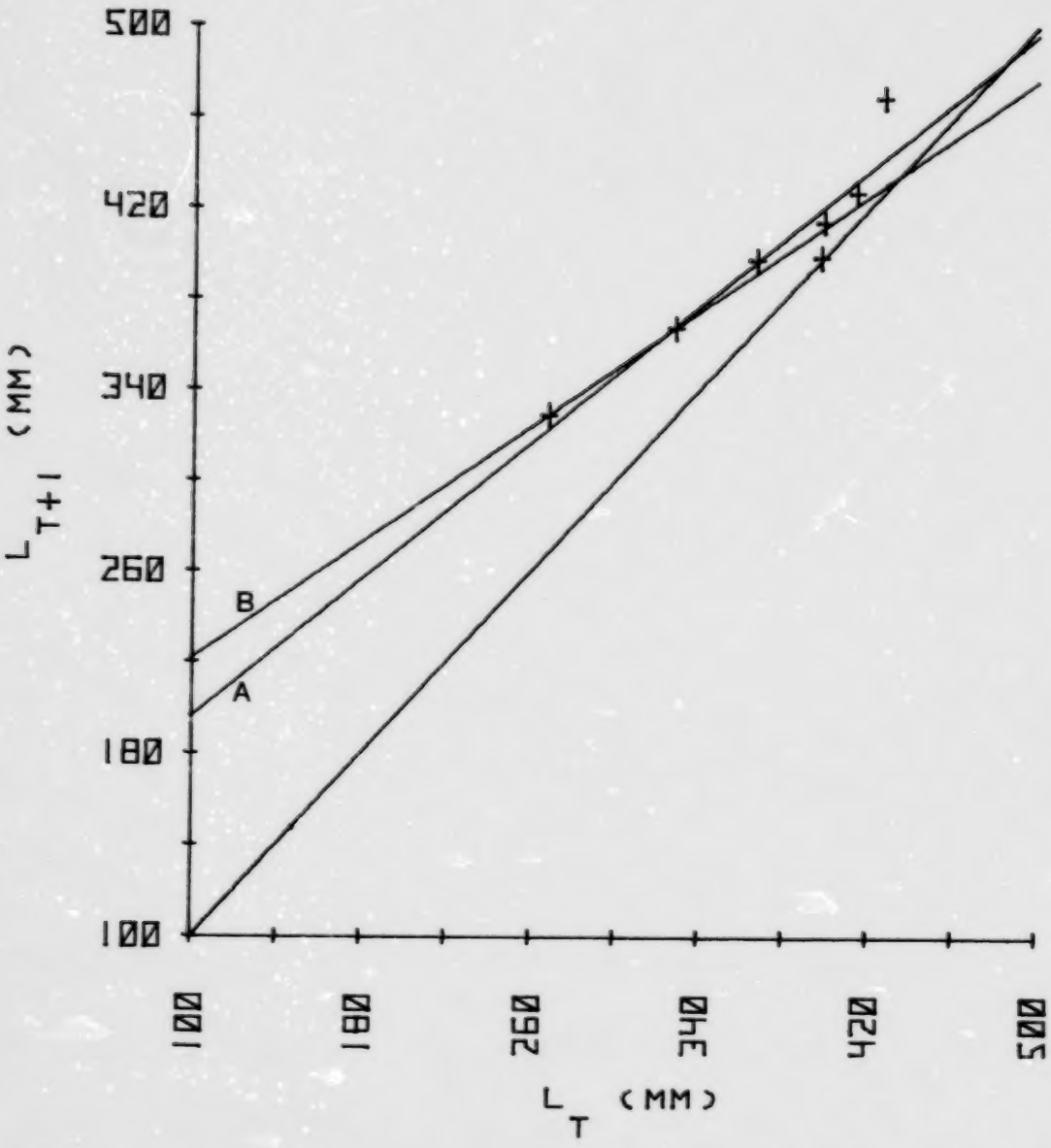


Fig. 15. Walford plot of southern walleye mean lengths. Curve A - all mean lengths, curve B - deleting mean lengths at ages 8-9.

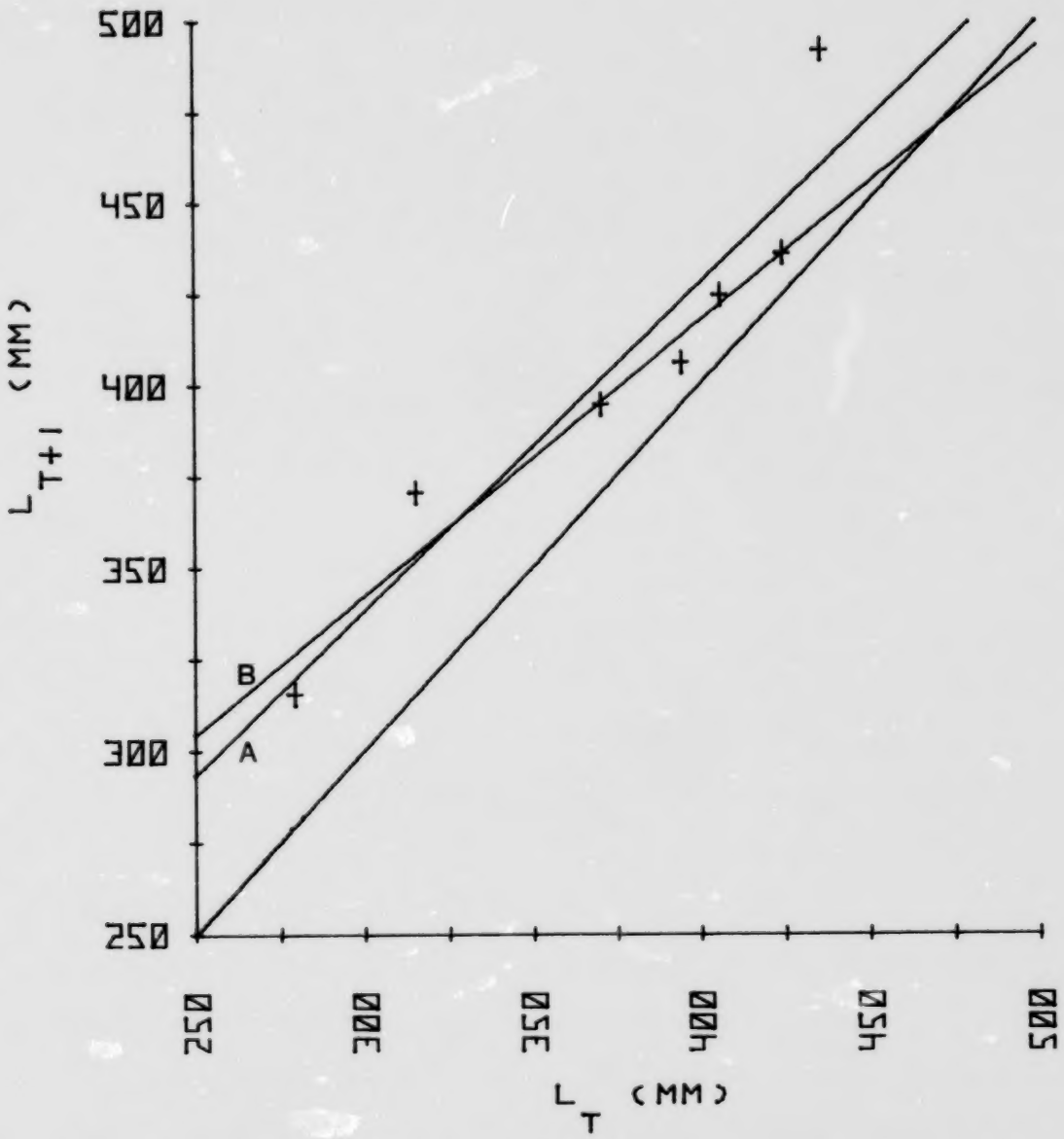


Fig. 16. Walford plots of northern whitefish mean lengths. Curve A - all lengths, curve B - deleting mean lengths at ages 8-10.

To determine growth rates, untransformed age-specific mean lengths were transformed according to the exponential and von Bertalanffy growth models (Table 12). Correlation coefficients of regressions of $\log_e (L_\infty - l_t)$ on t (Table 13, Figs. 17-21) were considered representative of the von Bertalanffy growth curve since these regressions provide estimates of parameters comprising the von Bertalanffy equation. The von Bertalanffy transformation produced slightly higher correlation coefficients in most cases (Table 12).

The exponential growth rate of southern saugers was not significantly faster than that of northern saugers (slopes $F = 1.13$, d.f. = 1, 19) but the southern sauger growth curve was significantly elevated above its northern counterpart (elevations $F = 12.66$, d.f. = 1, 20) (Fig. 22). The exponential growth rate of northern walleyes was significantly faster than that of southern walleyes (slopes $F = 17.28$, d.f. = 1, 13). However, the southern walleyes exponential growth curve was significantly elevated above the northern walleye growth curve (elevations $F = 7.96$ d.f. = 1, 14) (Fig. 23).

The rates and elevations of the best south basin sauger and walleye von Bertalanffy growth curves were significantly higher than those of the best north basin sauger and walleye von Bertalanffy growth curves (for saugers: slopes $F = 66.94$, 1 and 16 d.f., elevations F 58.85, 1 and 17 d.f.; for walleyes: slopes $F = 33.15$, 1 and 15 d.f., elevations $F = 46.13$, 1 and 13 d.f.) (Figs. 25-28).

Mesh size effects

The mean number of walleyes $mesh^{-1}$ was highest in the

Table 12. Exponential and von Bertalanffy growth curves of saugers, walleyes and whitefish from the northern and southern basins of Lake Winnipeg, 1981.

Species	Area	Growth curves: Exponential $\log_e$ length = a + b · $\log_e$ age	Age range (years)	R	Growth curves: von Bertalanffy $Length_t = L_\infty (1 - e^{-k(t - t_o)})$	R
Walleye	North	log Y = 5.069 + .492 logX	1-9	.992	(A) $L_t = 504.6\ (1 - e^{-.218(t + .752)})$	.994
					(B) $L_t = 483.68(1 - e^{-.261(t + .398)})$	.995
					(C) $L_t = 448.63(1 - e^{-.356(t - .042)})$	.996
	South	log Y = 5.409 + .331 logX	2-9	.979	(A) $L_t = 486.64(1 - e^{-.206(t + 2.461)})$	.979
					(B) $L_t = 434.59(1 - e^{-.474(t - 0.76)})$	.979
Sauger	North	log Y = 5.323 + .292 logX	2-13	.975	(A) $L_t = 415.28(1 - e^{-.280(t + .764)})$	.950
					(B) $L_t = 488.10(1 - e^{-.117(t + 4.0)})$	.984
	South	log Y = 4.972 + .421 logX	1-10	.987	(A) $L_t = 400.12(1 - e^{-.192(t + 1.674)})$	.981
					(B) $L_t = 368.00(1 - e^{-.227(t + 1.013)})$	.992
Whitefish	North	log Y = 5.407 + .338 logX (see Fig. 24)	2-10	.991	$L_t = 663.89(1 - e^{-.093(t + 4.18)})$ (see Fig. 29)	.986

Table 13. Relationship of $\log_e (L_\infty - l_t)$ and t (years) for walleyes, saugers and whitefish.

Species	Area	$\log_e (L_\infty - l_t) = a - b \cdot t$	R	Test F ratio and d.f.
Walleye	North	$\log_e (504.60 - l_t) = 6.056 - .218t$	.994	622.80 (1,7)
		$\log_e (483.68 - l_t) = 6.076 - .261t$	.995	640.54 (1,7)
		$\log_e (448.63 - l_t) = 6.125 - .356t$	.996	779.01 (1,6)
	South	$\log_e (486.64 - l_t) = 5.681 - .206t$	.979	117.74 (1,5)
		$\log_e (434.59 - l_t) = 6.110 - .474t$	.979	117.31 (1,5)
Sauger	North	$\log_e (488.10 - l_t) = 5.723 - .117t$	.950	82.88 (1,9)
		$\log_e (415.28 - l_t) = 5.815 - .280t$	.984	239.41 (1,8)
	South	$\log_e (400.12 - l_t) = 5.670 - .192t$	.981	181.62 (1,7)
		$\log_e (368.00 - l_t) = 5.678 - .227t$	.992	428.59 (1,7)
Whitefish	North	$\log_e (663.89 - l_t) = 6.109 - .093t$	.986	212.41 (1,6)

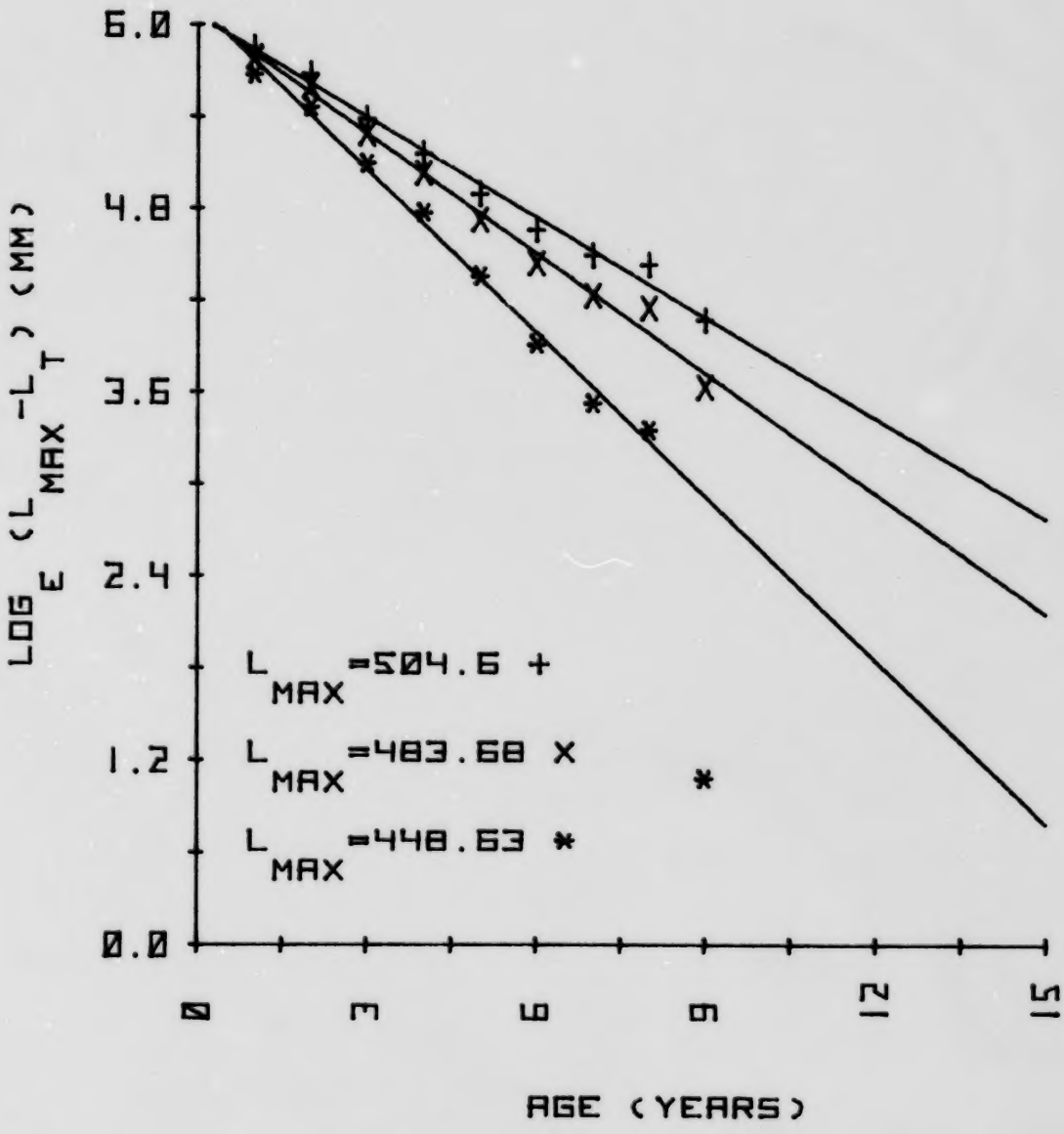


Fig. 17. Relation of $L_\infty - l_t$ and t using various L_∞ values for northern walleye stocks.

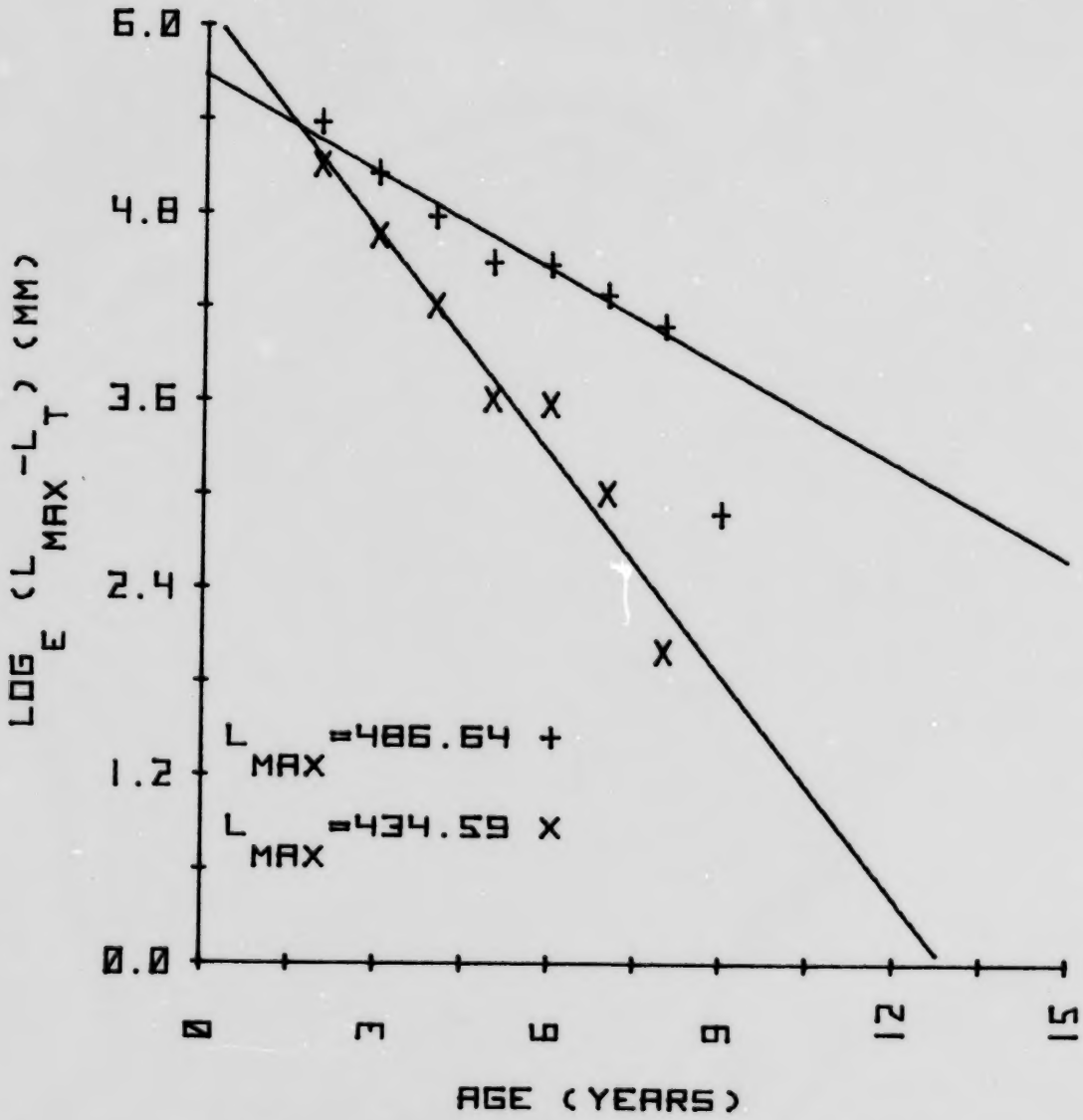


Fig. 18. Relation of $L_\infty - l_t$ and t using various L_∞ values for southern walleye stocks.

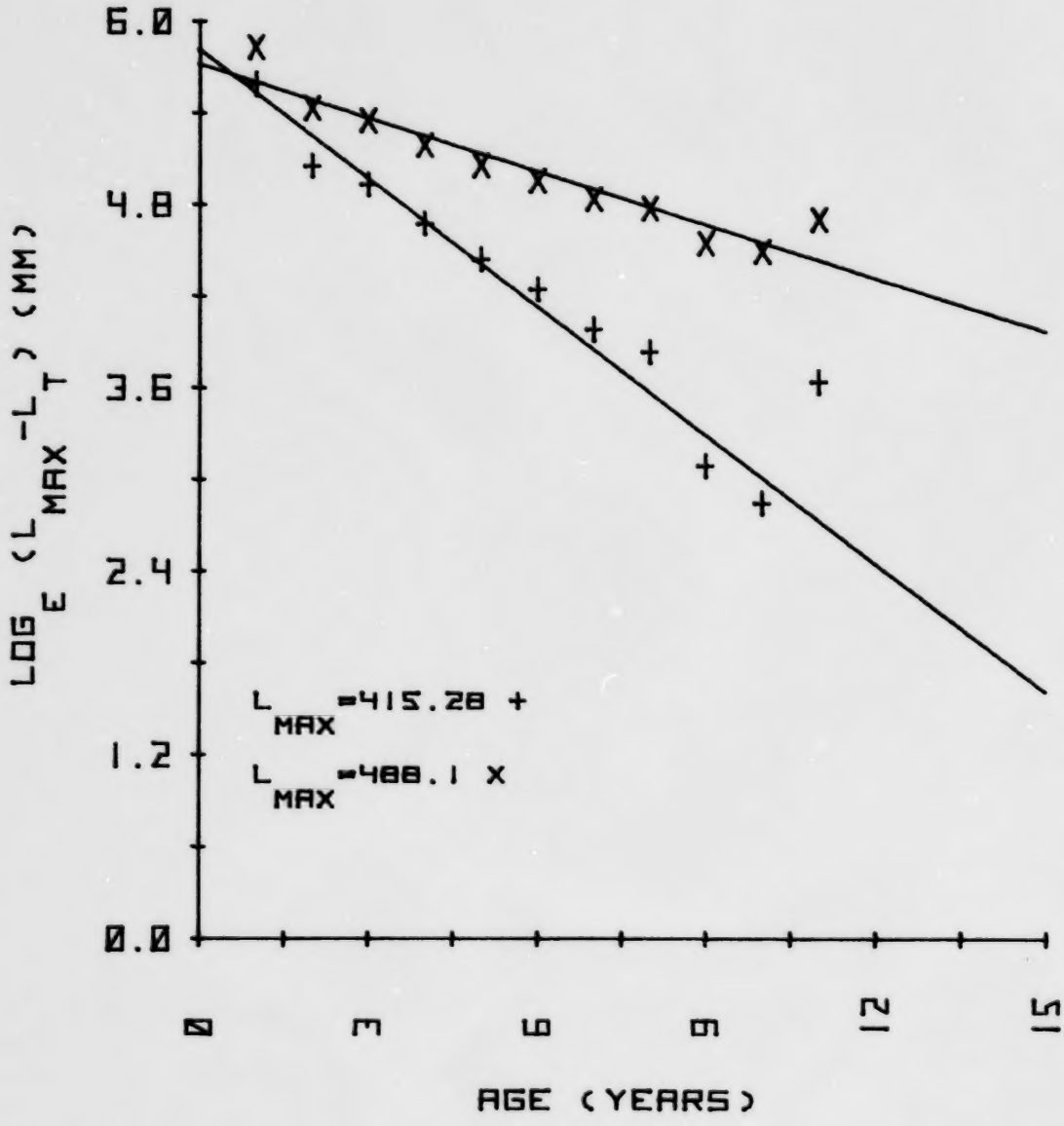


Fig. 19. Relation of $L_\infty - l_t$ and t using various L_∞ values for northern sauger stocks.

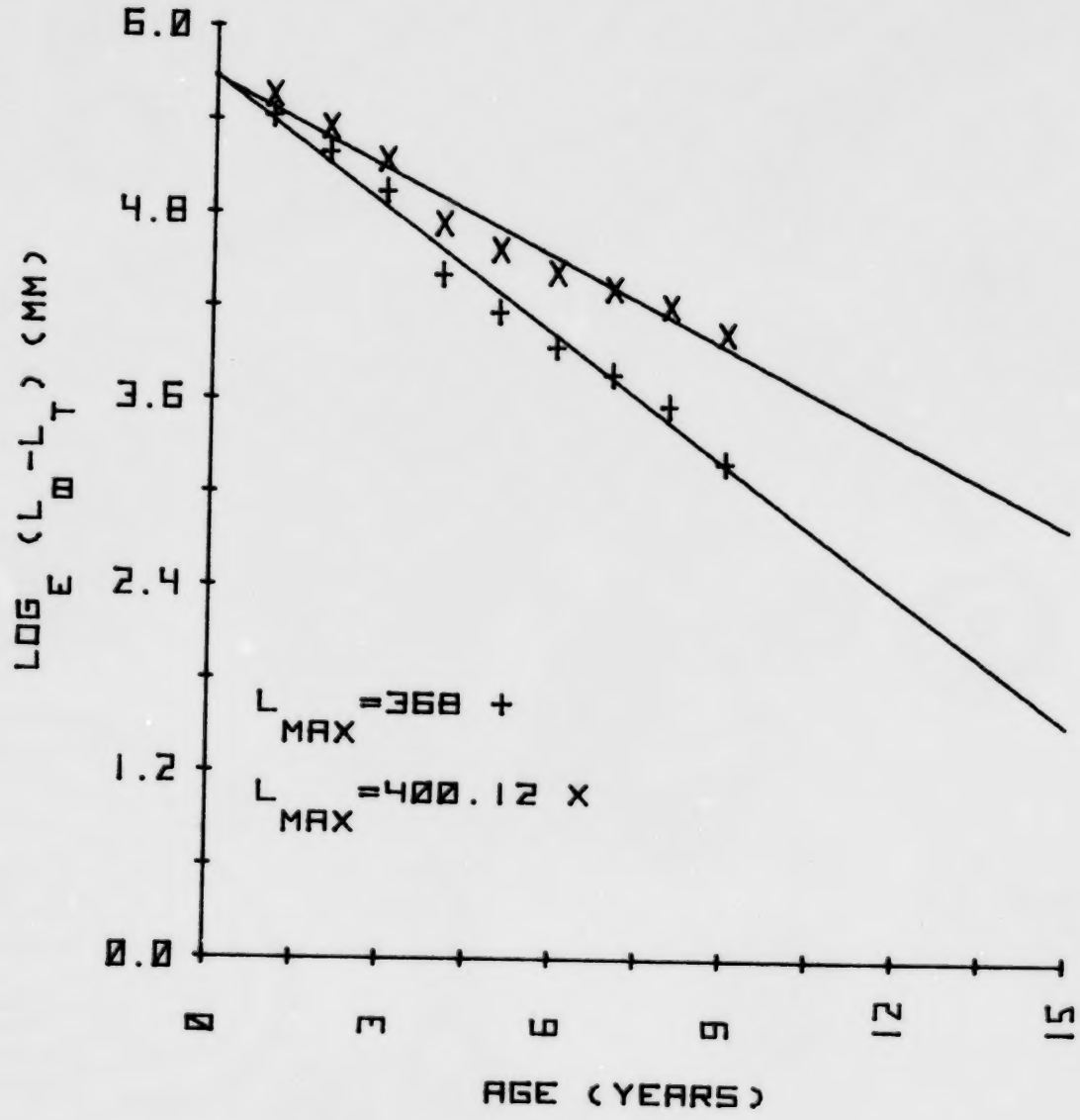


Fig. 20. Relation of $L_\infty - l_t$ and t using various L_∞ values for southern sauger stocks.

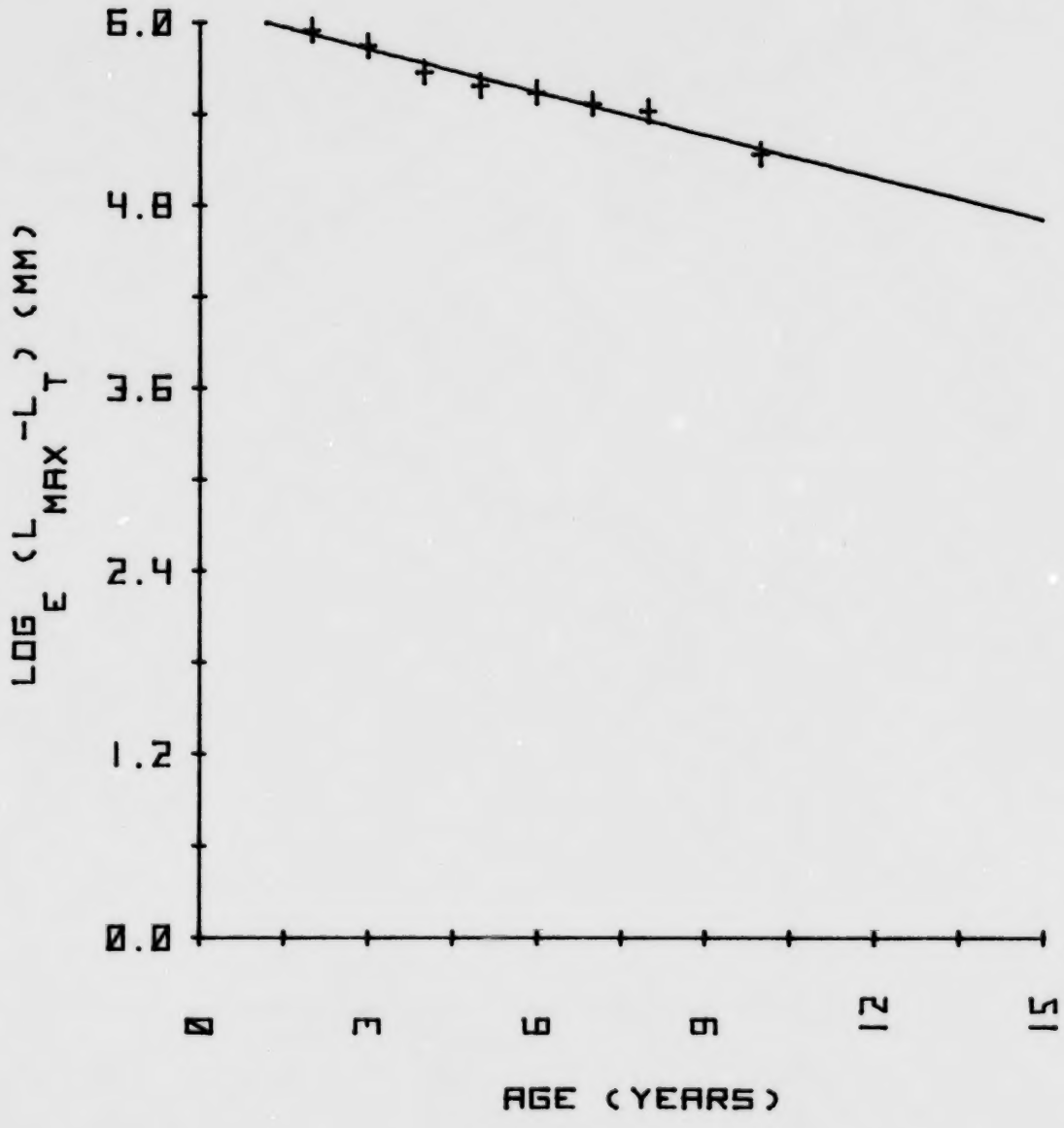


Fig. 21. Relation of $L_{\infty} - l_t$ and t for northern whitefish stocks.

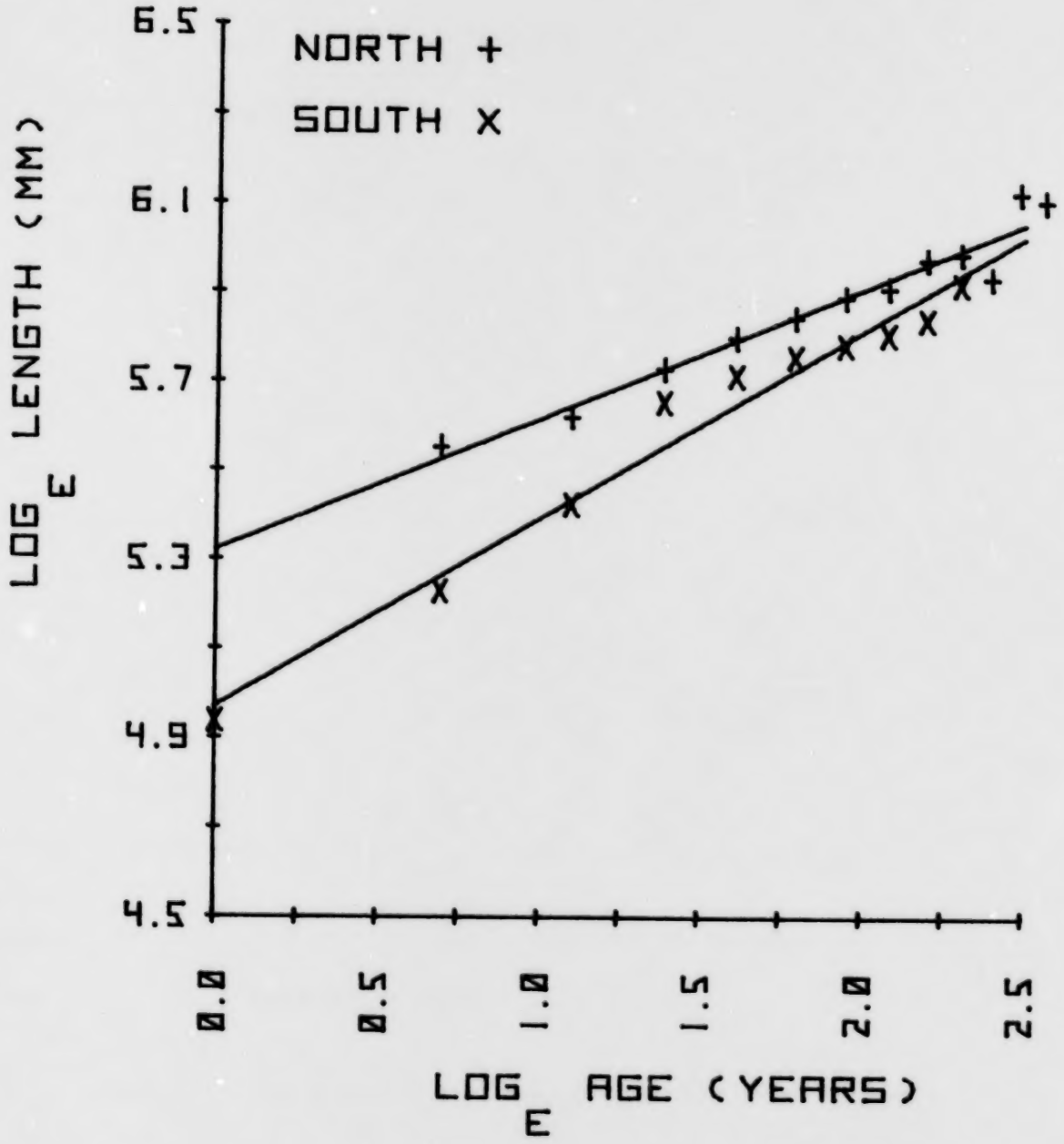


Fig. 22. Exponential growth curves of northern and southern sauger stocks.

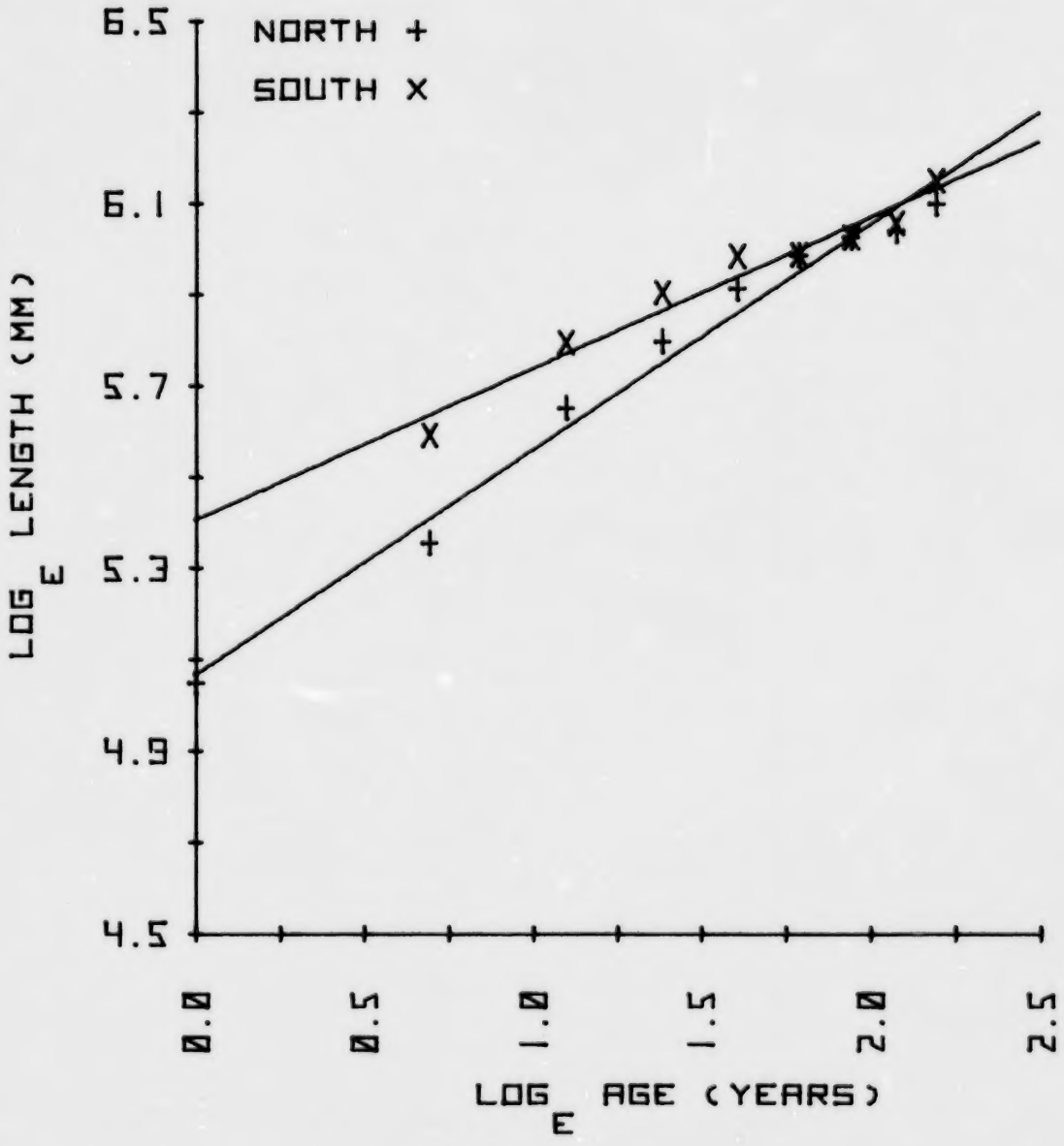


Fig. 23. Exponential growth curves of northern and southern walleye stocks.

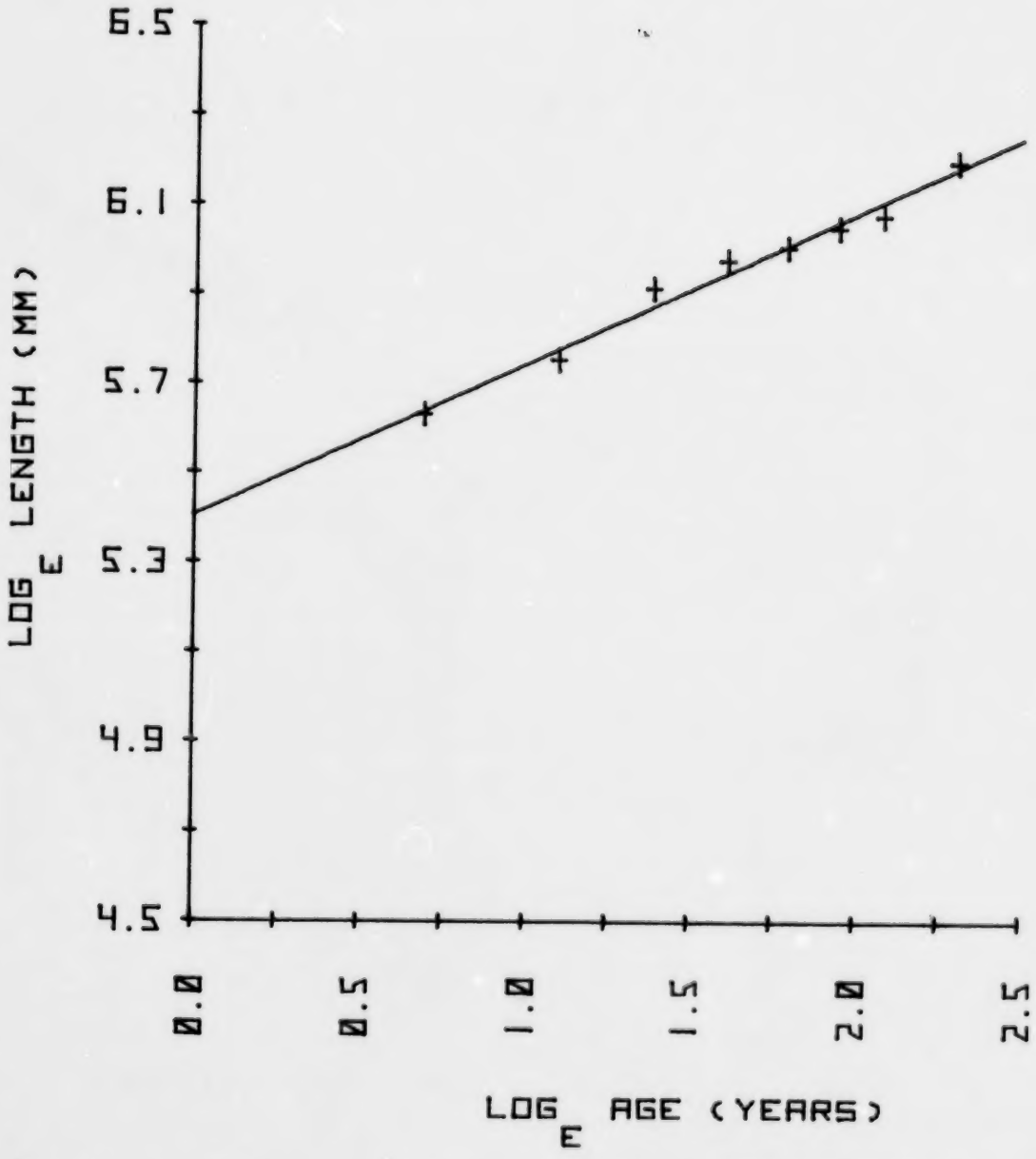


Fig. 24. Exponential growth curves of northern Lake Winnipeg whitefish.

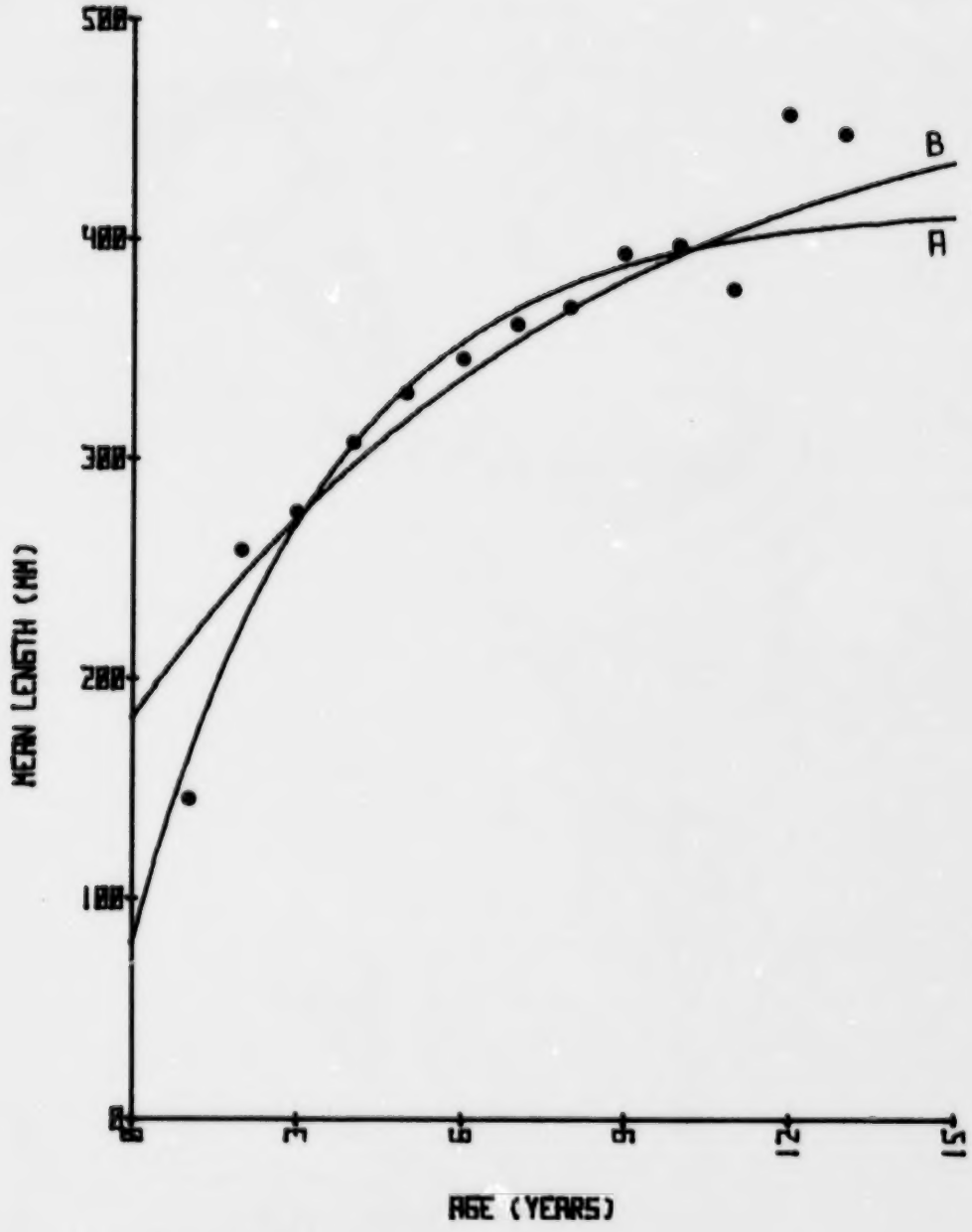


Fig. 25. Von Bertalanffy growth curves of north basin saugers (see Table 12).

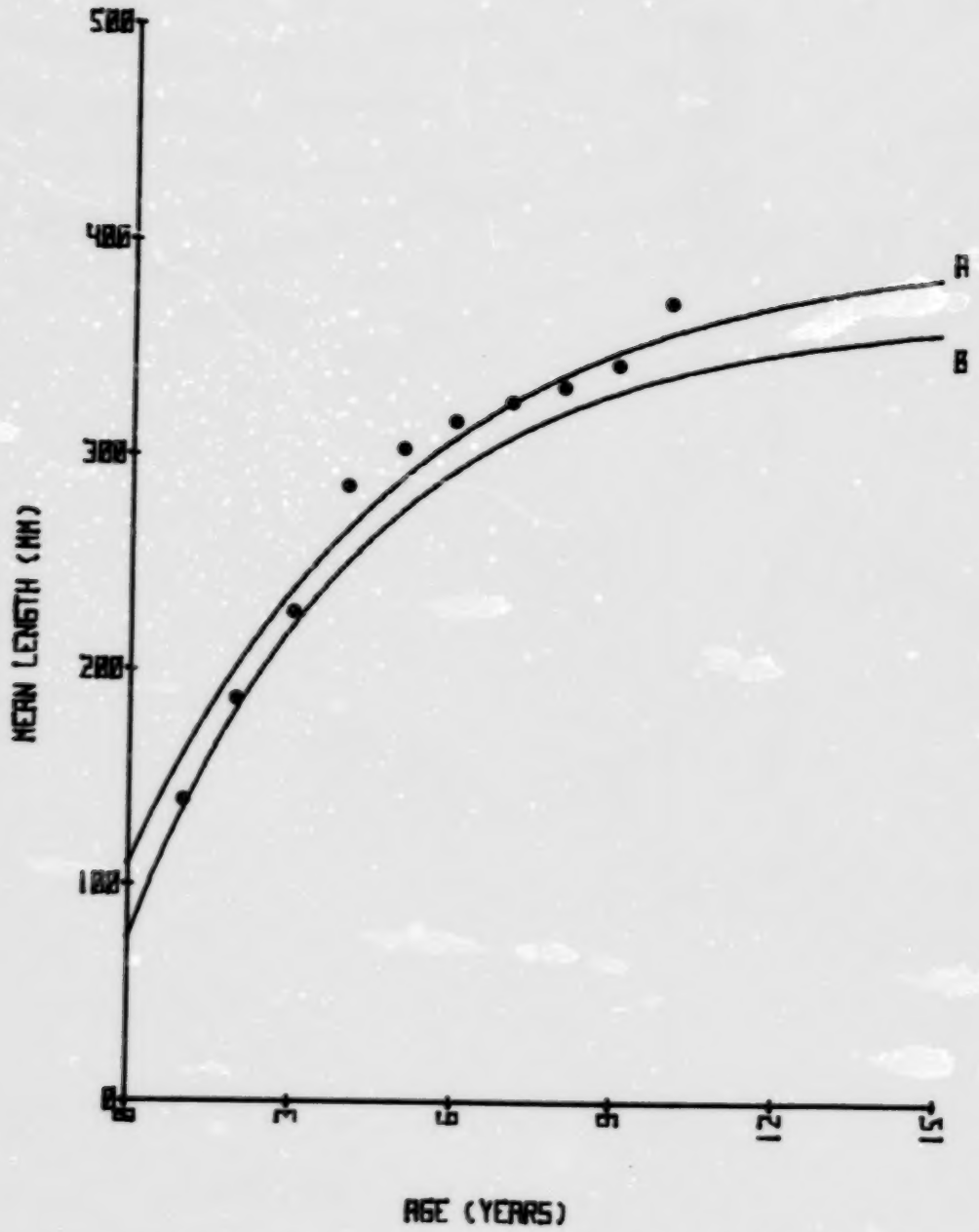


Fig. 26. Von Bertalanffy growth curves of south basin saugers (see Table 12).

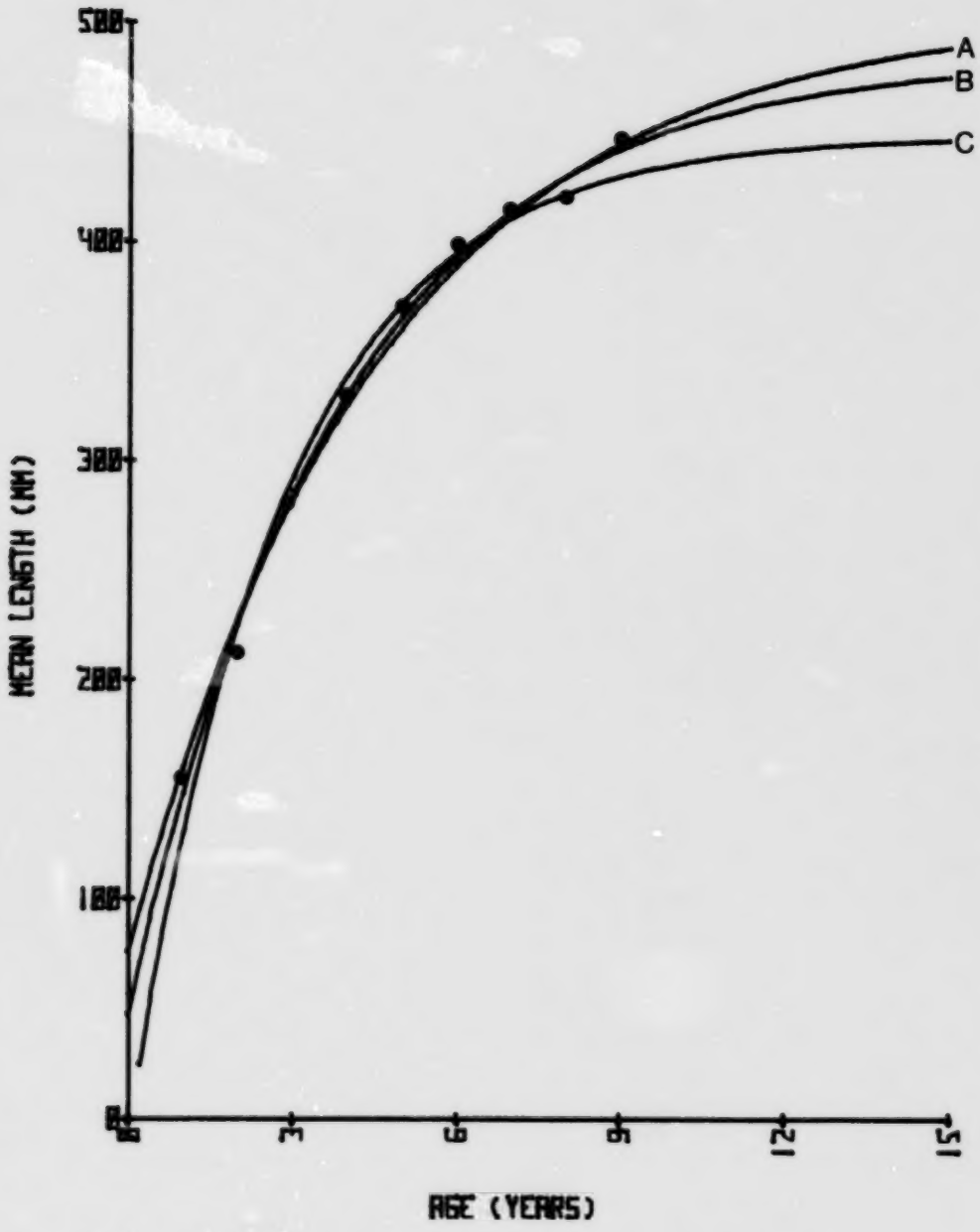


Fig. 27. Von Bertalanffy growth curves of north basin walleyes (see Table 12).

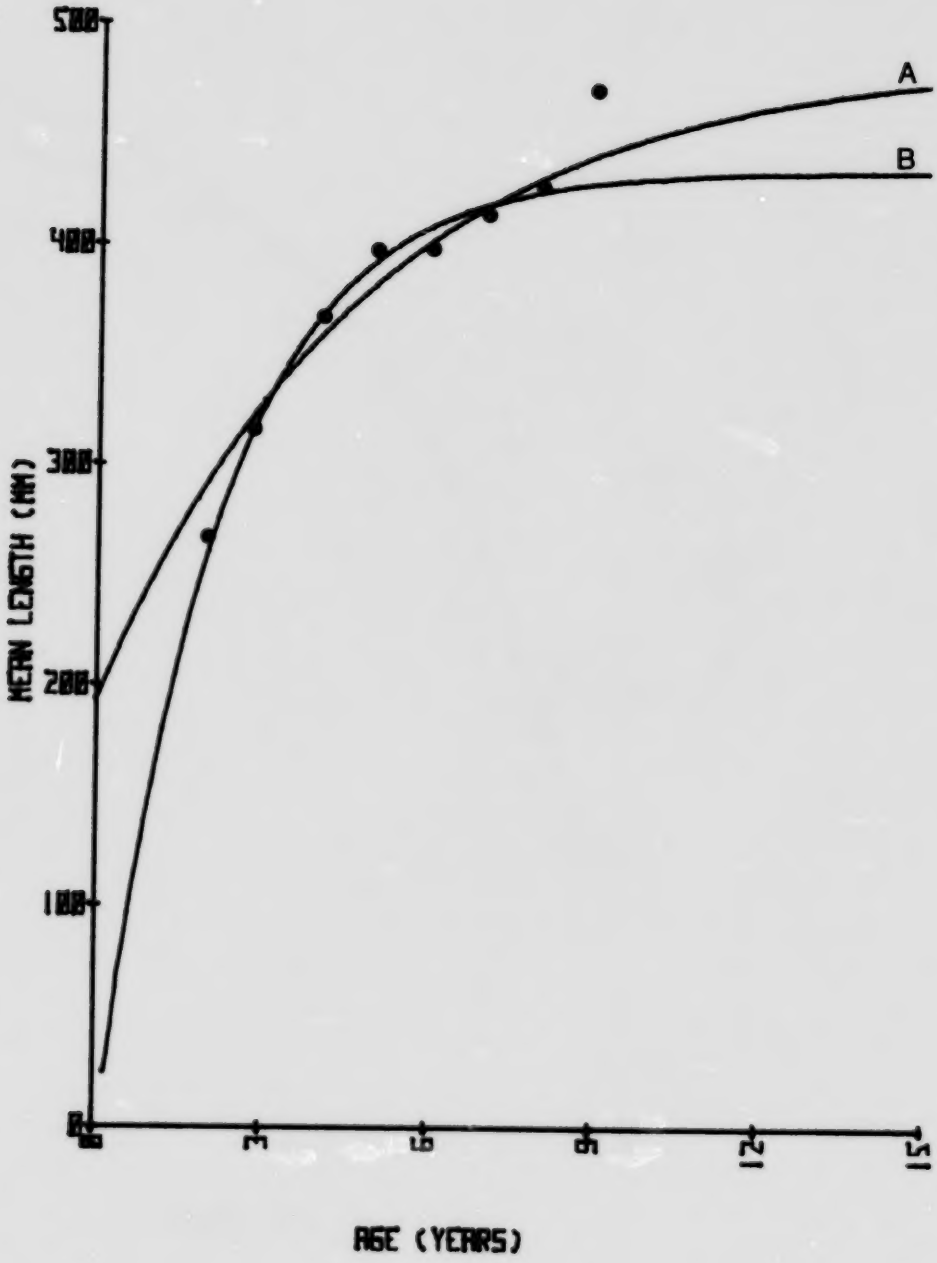


Fig. 28. Von Bertalanffy growth curves of south basin walleyes (see Table 12).

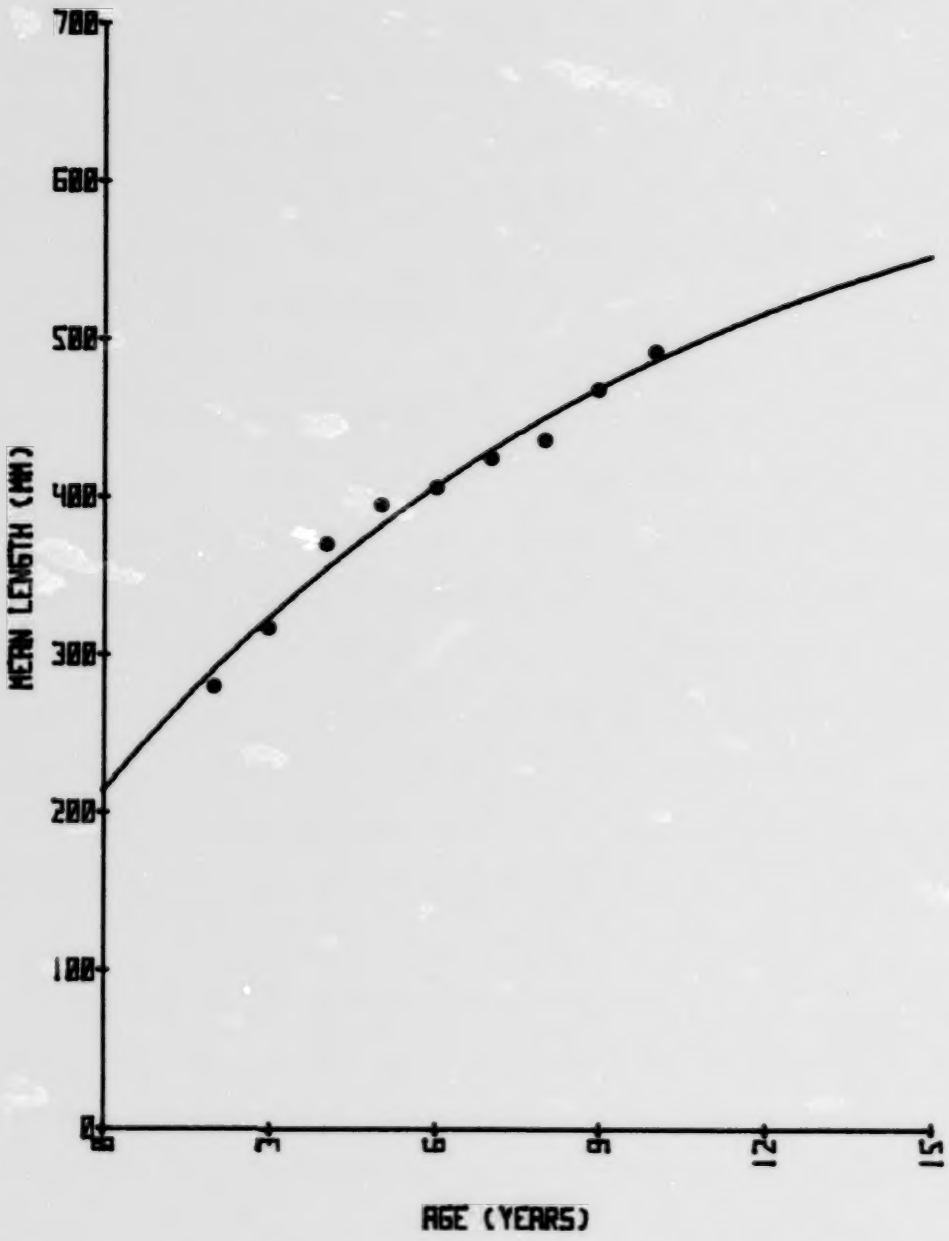


Fig. 29. Von Bertalanffy growth curve of Lake Winnipeg whitefish.

3 inch (76.2 mm) mesh and decreased with increasing mesh size in the south basin. The 3 inch (76.2 mm) mesh caught fewer walleyes in the north basin than in the south basin. Mean numbers of walleyes caught in meshes larger than 3 inch (76.2 mm) were higher in the north basin than in the south basin (Fig. 30, Tables 14,15). Mean ages of walleyes caught in all meshes of the experimental gang were older in the north basin than in the south basin (Tables 14, 15). Although mean individual weights of walleyes caught in larger meshes in the north basin were generally lower than those of southern walleyes (Fig. 31), mean numbers of walleyes net^{-1} were higher in the north basin (Fig. 30). Consequently, the mean biomass of walleyes net^{-1} in the north basin was greater than or equal to the mean biomass of southern walleyes net^{-1} in the south basin for the majority of mesh sizes comprising the experimental gangs (Fig. 32). Frequencies of immature walleyes $mesh^{-1}$ decreased faster with increasing mesh size in the south basin. Frequencies of immature walleyes were higher in all meshes in the north basin than in the south basin (Fig. 33, Tables 14, 15).

The mean number of saugers $mesh^{-1}$ was highest in the 3 inch (76.2 mm) mesh and declined with increasing mesh size in both northern and southern basins. Mean numbers of saugers caught in all meshes were higher in the south basin (Fig. 34). However mean individual sizes of saugers caught in all meshes in the south basin were substantially smaller than sizes of northern saugers

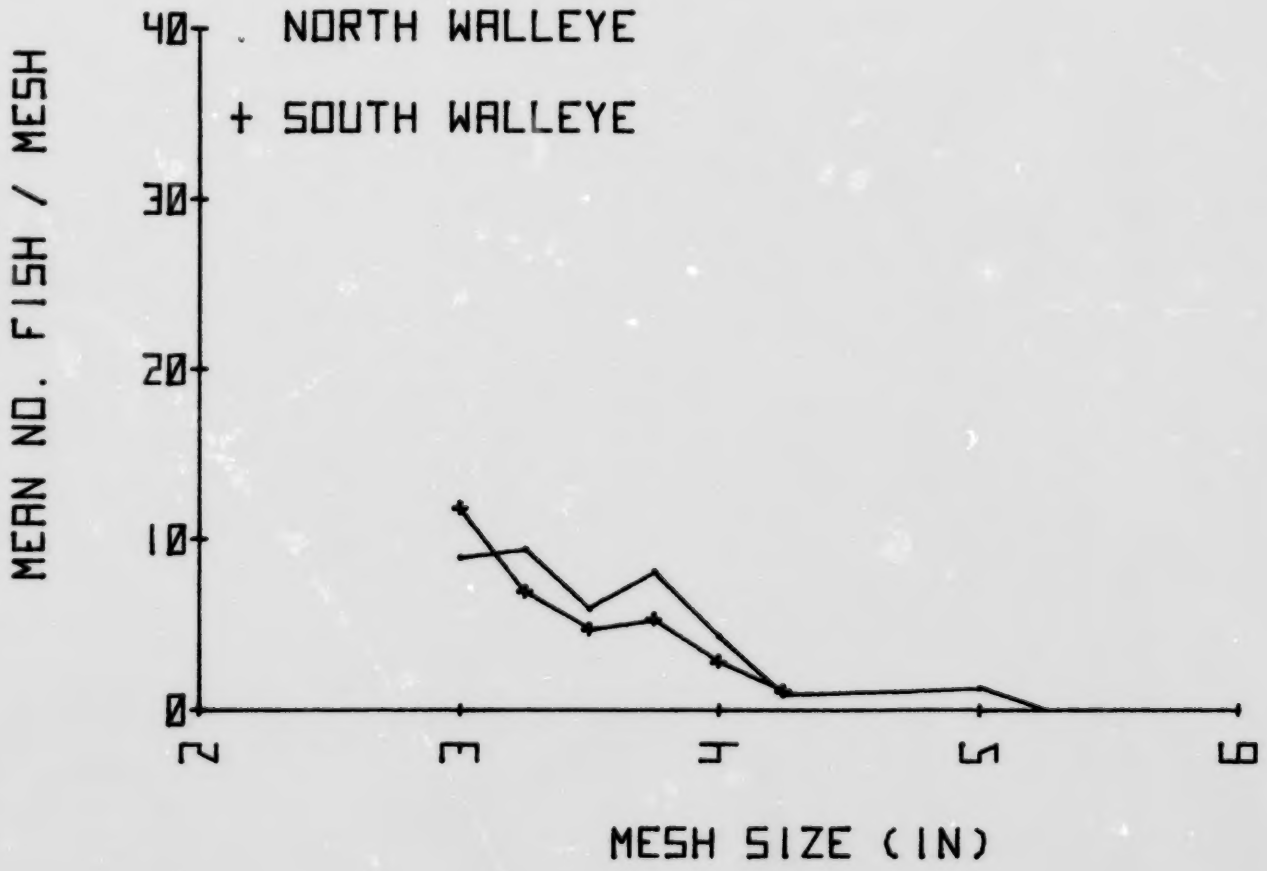


Fig. 30. Effects of mesh size on the mean numbers of walleyes mesh^{-1} in the northern and southern basins of Lake Winnipeg.

Table 14. North basin walleye mesh size effects.

Parameter	Mesh size (inches)							
	3	3.25	3.5	3.75	4	4.25	5	5.25
no. fish	98	103	65	89	47	10	14	0
no. immature	92	84	48	65	28	8	8	
% immature	93.9	81.6	73.8	73.0	59.6	80.0	57.1	
mean length (mm)	359.47	363.24	391.29	396.63	405.53	430.20	357.29	
mean weight (gm)	543.98	549.90	696.92	692.81	782.13	1008.00	567.14	
Age (years)				Frequency (%)				
1		.97						
2			3.08		2.13	10.0		
3	4.08			1.12	2.13	10.0	7.14	
4	25.51	21.36	6.15	3.37	2.13	20.0	21.43	
5	35.71	46.60	29.23	31.46	14.89	40.0	28.57	
6	21.43	20.39	40.00	35.96	36.17	10.0	21.43	
7	7.14	6.80	10.77	20.22	19.15	10.0	14.29	
8	6.12	3.88	7.69	7.87	17.02		7.14	
9			3.08		6.38			
mean age (years)	5.2	5.2	5.8	5.9	6.4	4.6	5.4	
mean biomass mesh^{-1} (kg)	4.85	5.15	4.12	5.61	3.34	0.92	0.72	
mean no. fish mesh^{-1}	8.9	9.4	5.9	8.1	4.3	0.9	1.3	

Table 15. South basin walleye mesh size effects.

Parameter	Mesh size (inches)					
	3	3.25	3.50	3.75	4	4.25
no. fish	117	103	70	79	42	16
no. immature	131	60	29	30	17	16
% immature	74.0	58.3	41.4	38.0	40.5	100
mean length (mm)	329.16	349.97	397.77	385.85	421.24	471.88
mean weight (gm)	406.89	495.83	738.50	677.77	902.26	1226.25
Age (years)			Frequency (%)			
1						
2	4.52	.97	1.43		4.76	
3	71.75	48.54	17.14	18.99	2.38	
4	8.47	14.56	15.71	15.19		
5	8.47	26.21	40.00	40.51	42.86	31.25
6	2.82	2.91	11.43	5.06	7.14	
7	2.82	3.88	14.29	20.25	33.33	62.50
8	1.13	1.94			2.38	
9		.97			7.14	6.25
10						
11						
12						
mean age (years)	2.9	4.1	4.8	4.9	5.9	6.5
mean biomass mesh^{-1} (kg)	4.80	3.40	3.45	3.57	2.53	1.31
mean no. fish mesh^{-1}	11.8	6.9	4.7	5.3	2.8	1.1

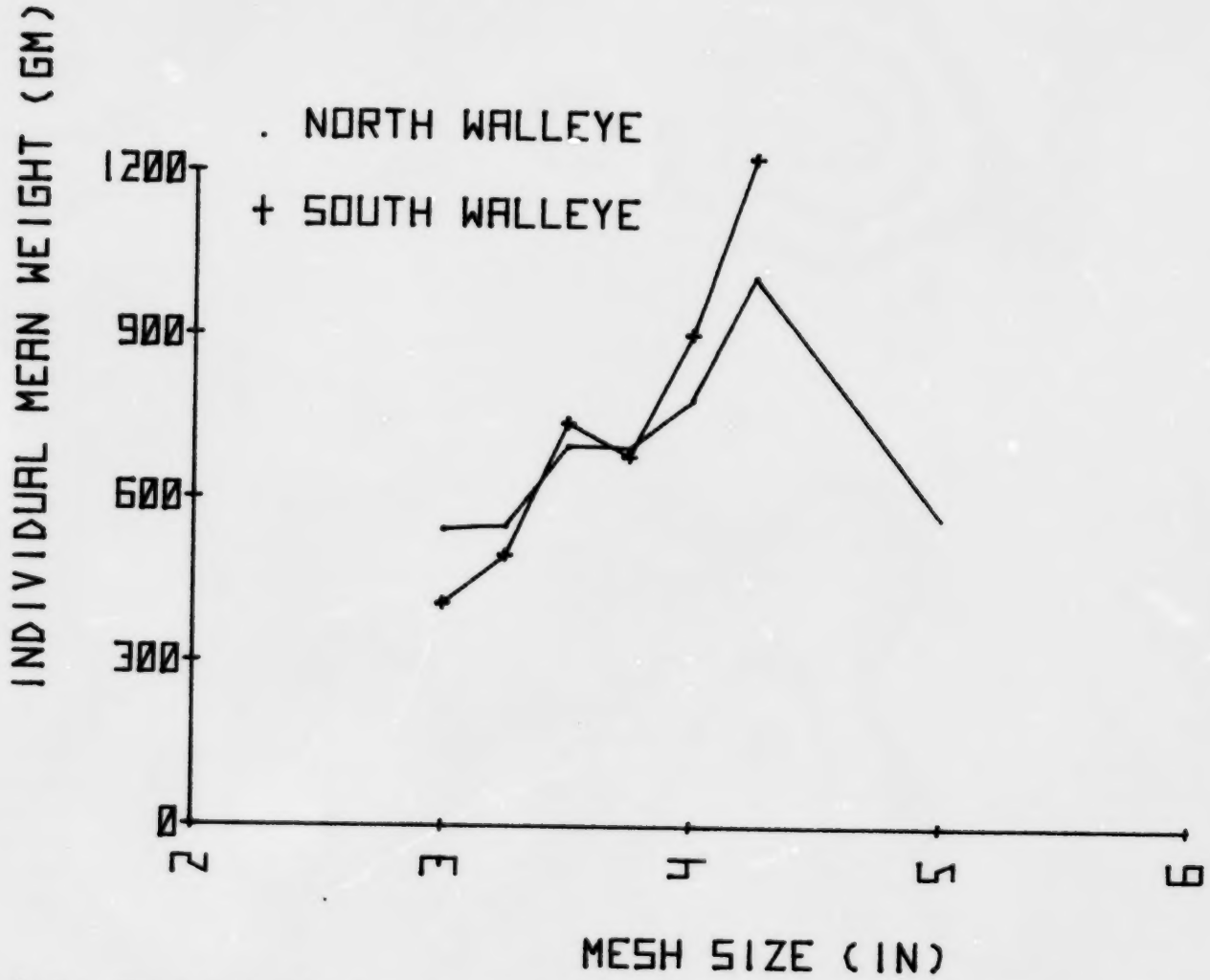


Fig. 31. The relationship of mean weights of walleyes and mesh sizes in northern and southern Lake Winnipeg.

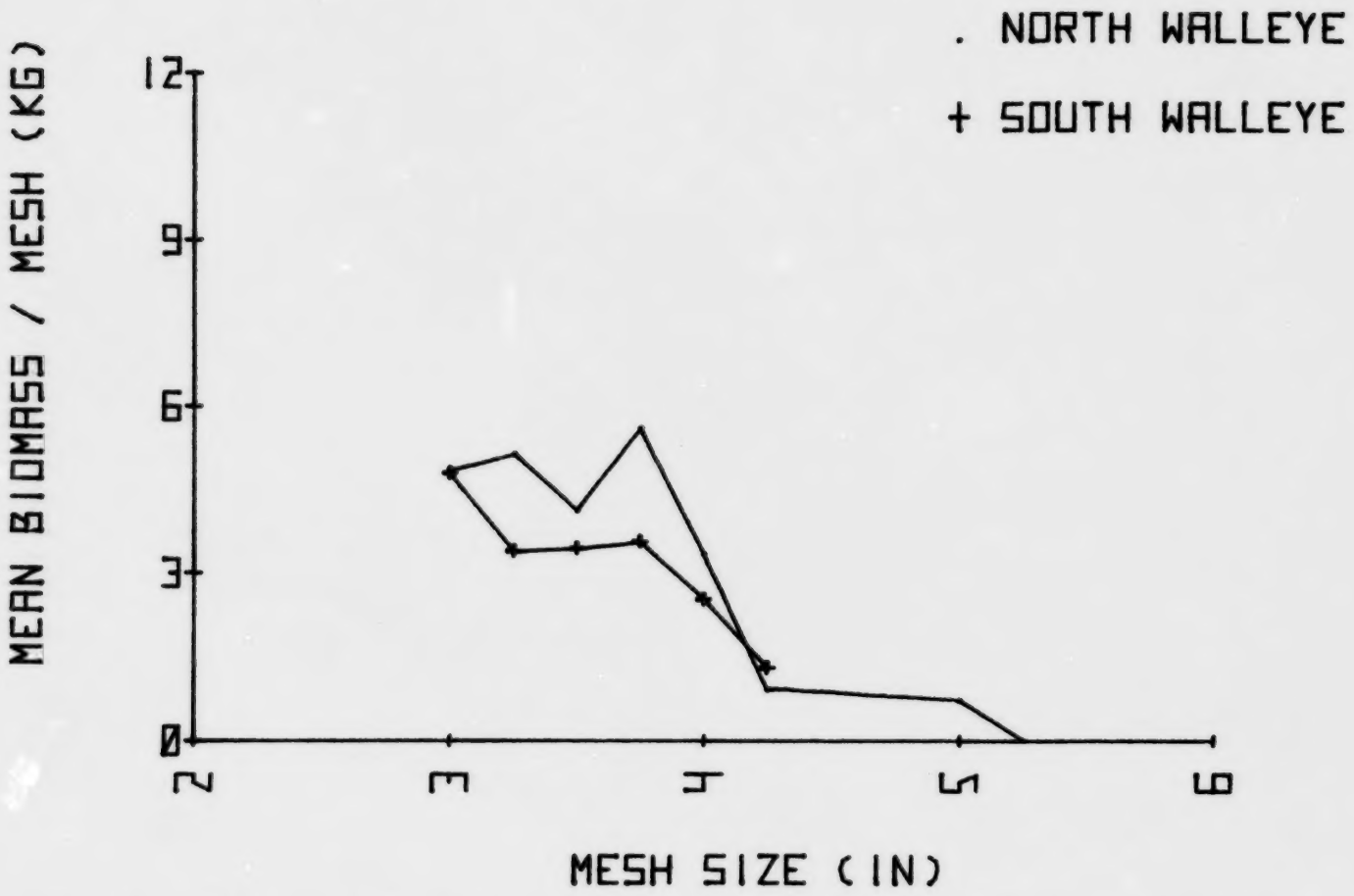


Fig. 32. Changes in mean biomass of walleyes per net in relation to mesh size in northern and southern Lake Winnipeg.

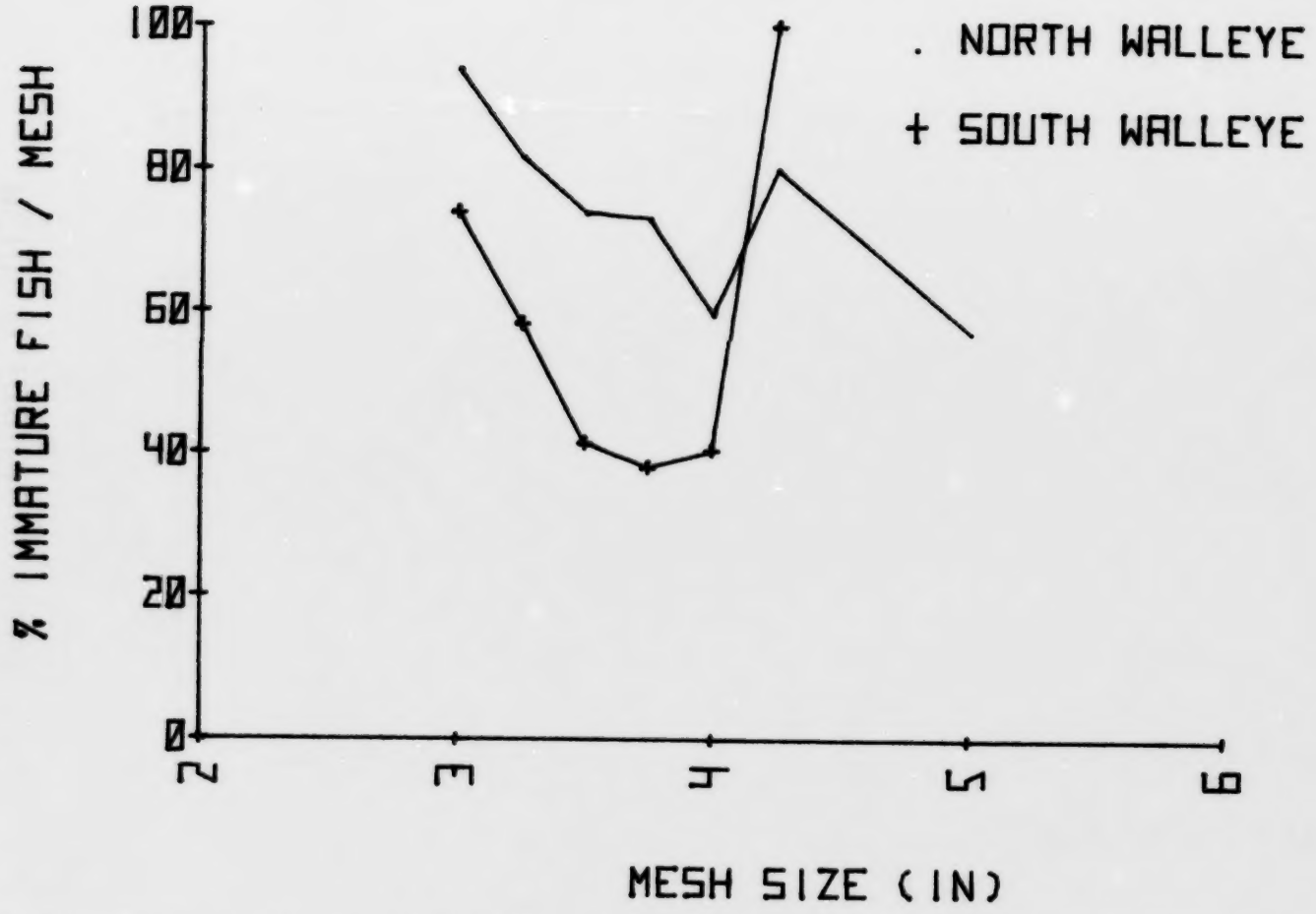


Fig. 33. Changes in frequencies of immature walleyes in relation to mesh size in northern and southern Lake Winnipeg.

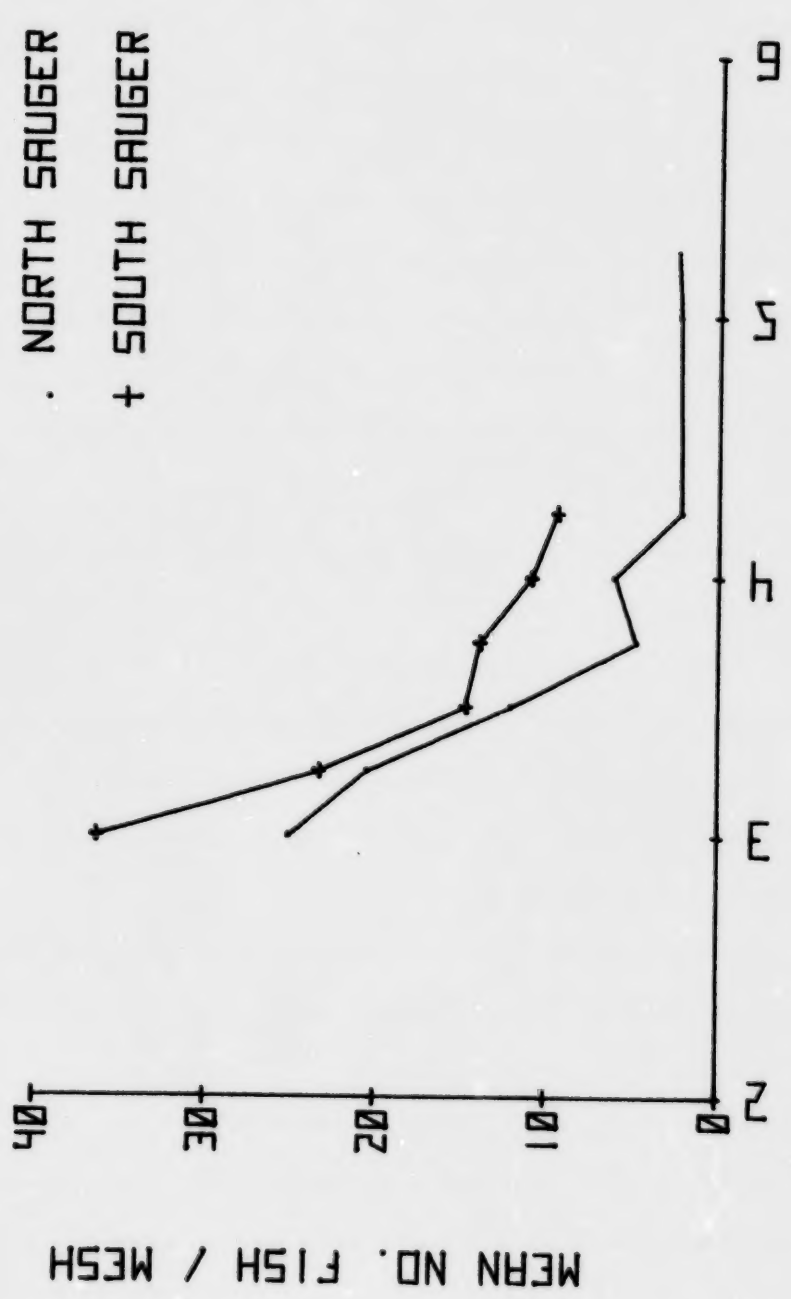


Fig. 34. Effects of mesh size on the mean numbers of saugers mesh^{-1} in the northern and southern basins of Lake Winnipeg.

(Fig. 35). The mean biomass net^{-1} of saugers decreased with increasing mesh size in both basins. The 3 (76.2 mm), 3.75 (95.25 mm) and 4.25 inch (107.95 mm) meshes captured more sauger biomass in the south basin than in the north basin (Fig. 36). Frequencies of immature saugers caught by the 3 inch (76.2 mm) mesh were almost equal in both basins. Meshes larger than 3 inch (76.2 mm) captured substantially more immature saugers in the south basin than in the north basin (Fig. 37). Mean ages of saugers caught in all meshes of the experimental gang were older in the north basin. Mean ages of saugers remained relatively constant from mesh to mesh in both basins (Tables 16, 17).

Mean lengths and weights of whitefish increased with increasing mesh size. Mean numbers of whitefish net^{-1} increased from the 3 inch (76.2 mm) mesh to the 3.75 inch (95.25 mm) mesh and decreased thereafter. Frequencies of immature whitefish were highest in the 3 inch (76.2 mm) mesh and decreased with increasing mesh size. Mean ages of whitefish increased with increasing mesh size (Table 18).

Three, five and seven year old walleyes dominated the age frequency distribution of walleyes caught by the experimental gangs set in the south basin (Fig. 38). 71% of the walleyes captured by the 3 inch (76.2 mm) mesh were 3 years old. The 3.25 (82.55 mm) and 3.5 inch (88.9 mm) mesh caught walleyes that were predominantly 3 and 5 years old while larger meshes caught

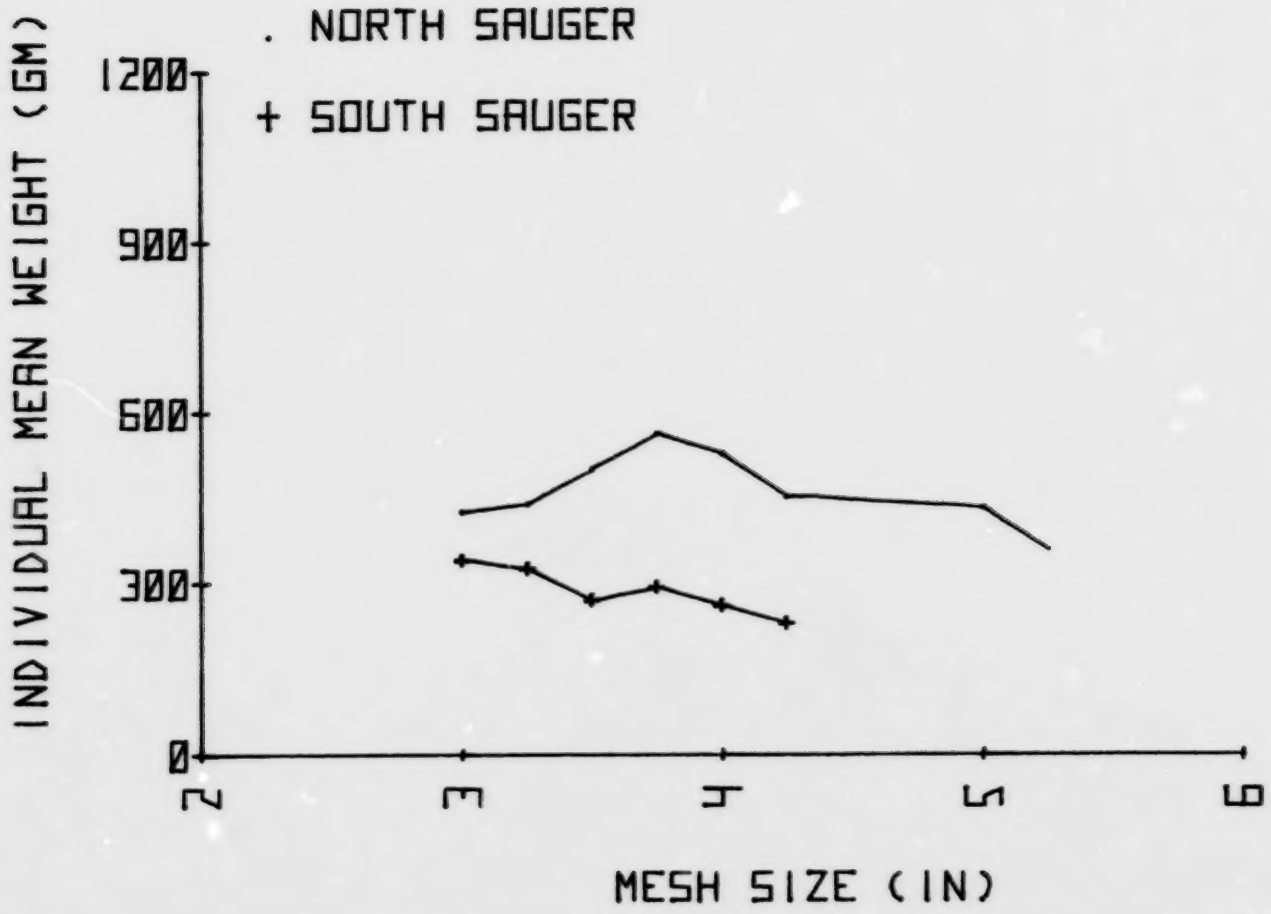


Fig. 35. The relationship of mean weights of saugers and mesh sizes in northern and southern Lake Winnipeg.

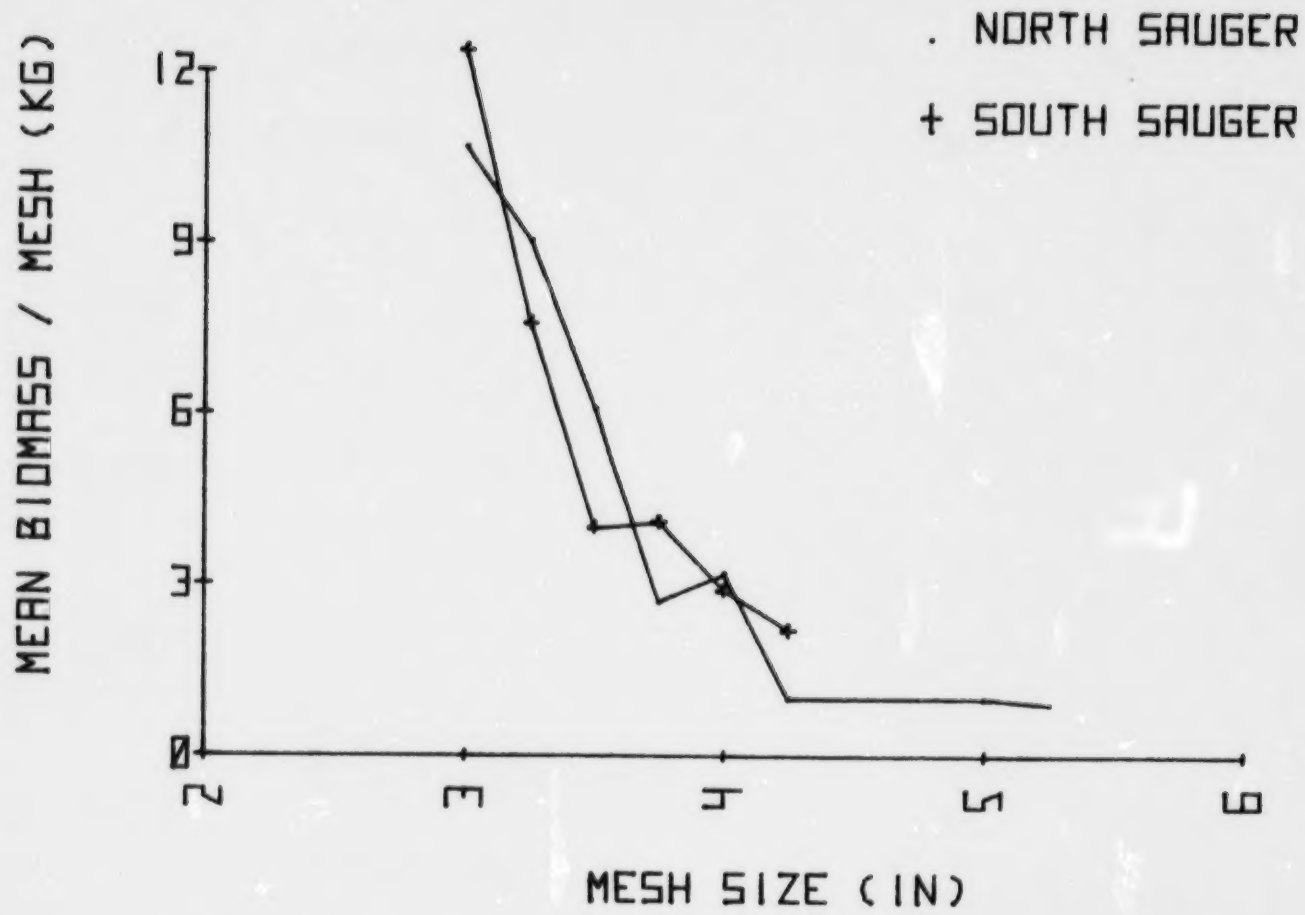


Fig. 36. Changes in mean biomass of saugers net^{-1} in relation to mesh size in northern and southern Lake Winnipeg.

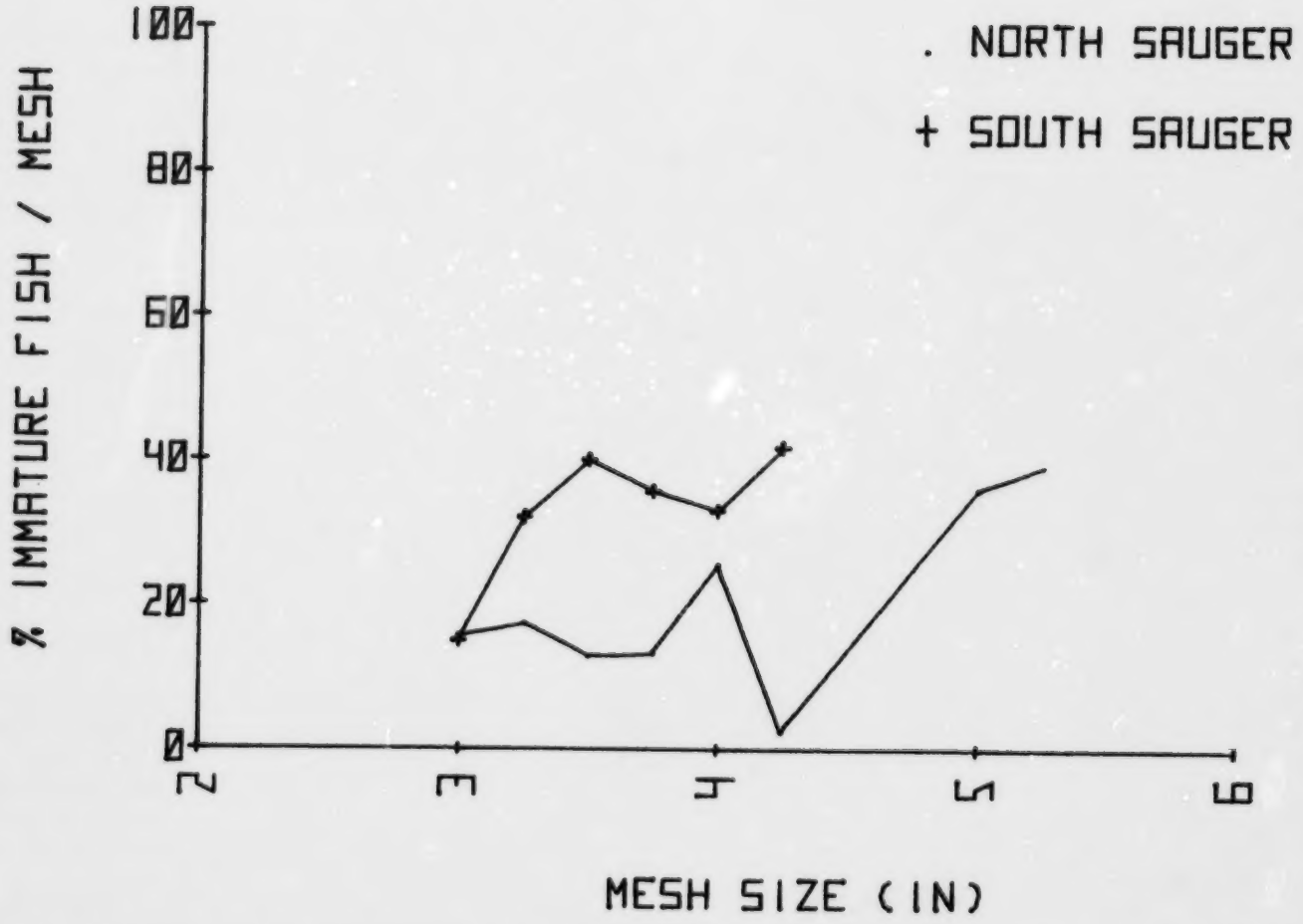


Fig. 37. Changes in frequencies of immature saugers in relation to mesh size in northern and southern Lake Winnipeg.

Table 16. North basin sauger mesh size effects.

Parameter	Mesh size (inches)							
	3	3.25	3.50	3.75	4	4.25	5.00	5.25
no. fish	276	226	133	53	67	24	25	28
no. immature	43	39	17	7	17	5	9	11
% immature	15.6	17.3	12.8	13.2	25.4	2.5	36.0	39.3
mean length (mm)	341.24	343.73	352.03	362.38	350.27	333.67	326.16	314.29
mean weight (gm)	426.56	440.22	500.75	563.58	528.81	454.17	432.80	359.57
Age (years)				Frequency (%)				
1			.75					
2					2.99			7.14
3	.72	2.65	1.50	3.77	1.49	16.67	12.00	17.86
4	6.16	9.29	6.02	7.55	10.45	20.83	16.00	21.43
5	30.43	16.81	15.04	24.53	20.90	16.67	16.00	25.00
6	36.93	38.50	23.31	24.53	19.40	12.50	20.00	14.29
7	11.23	21.68	22.56	20.75	19.40	4.17	16.00	3.57
8	10.87	7.52	21.80	11.32	13.43	20.83	12.00	3.57
9	1.81	3.10	8.27	5.66	10.45		8.00	7.14
10	.72	.44		1.89	1.49	8.33		
11	.36		.75					
12	.36							
13	.36							
mean age (years)	6.0	6.0	6.6	6.2	4.9	5.0	5.8	4.8
mean biomass mesh^{-1} (kg	10.7	9.04	6.1	2.7	3.2	1.0	1.0	0.9
mean no. fish mesh^{-1}	25.1	20.5	12.1	4.8	6.1	2.2	2.3	2.5

Table 17. South basin sauger mesh size effects.

Parameter	Mesh size (inches)					
	3	3.25	3.5	3.75	4	4.25
no. fish	545	350	220	208	164	141
no. immature	81	112	88	74	54	59
% immature	14.9	32.0	40	35.6	32.9	41.8
mean length (mm)	310.26	296.02	282.09	285.81	278.83	270.99
mean weight (gm)	340.74	325.91	269.39	293.65	260.84	229.86
Age (years)			Frequency (%)			
1		.57	.45	.96	.61	
2	2.75	8.29	8.18	10.58	9.76	12.06
3	5.87	9.71	22.73	10.10	15.85	19.86
4	4.77	5.71	4.55	7.21	9.15	10.64
5	19.08	16.86	18.18	23.08	19.51	23.40
6	41.28	32.57	29.55	26.44	22.56	21.99
7	22.39	23.71	15.00	17.31	14.63	7.80
8	3.85	2.57	1.36	3.85	4.88	3.55
9				.48	2.44	.71
10					.61	
mean age (years)	5.7	3.7	4.9	5.1	5.1	4.7
mean biomass mesh^{-1} (kg)	12.38	7.6	4.0	4.1	2.9	2.2
mean no. fish mesh^{-1}	36.3	23.3	14.7	13.9	10.9	9.4

Table 18. North basin whitefish mesh size effects.

Parameter	Mesh size (inches)							
	3	3.25	3.50	3.75	4	4.25	5	5.25
no. fish	293	365	498	508	470	336	408	163
no. immature	229	270	301	268	215	136	129	34
% immature	78.2	74.0	60.4	52.8	45.7	40.5	31.6	20.9
mean length (mm)	326.96	342.11	372.37	379.42	387.78	393.45	411.08	418.43
mean weight (gm)	535.63	600.82	772.33	809.51	868.52	901.76	1048.58	1128.59
Age (years)				Frequency (%)				
1								
2	5.80	1.64	.2					
3	50.17	34.25	18.47	14.76	6.38	3.87		
4	23.55	33.97	31.73	31.30	32.55	27.68	12.50	14.72
5	12.97	23.01	32.13	35.43	40.85	45.54	47.55	39.88
6	7.17	6.30	15.26	15.55	17.66	18.45	32.60	32.52
7	.34	.55	2.21	2.36	2.55	4.17	5.88	10.43
8		.27		.59		.3	1.23	2.45
9								
10							.25	
11								
12								
mean age (years)	3.7	4.0	4.5	4.6	4.8	4.9	5.4	5.5
mean biomass mesh^{-1} (kg)	14.27	19.94	34.97	37.38	37.11	27.54	38.89	16.72
mean no. fish mesh^{-1}	26.6	33.2	45.3	46.2	42.7	30.5	37.1	14.8

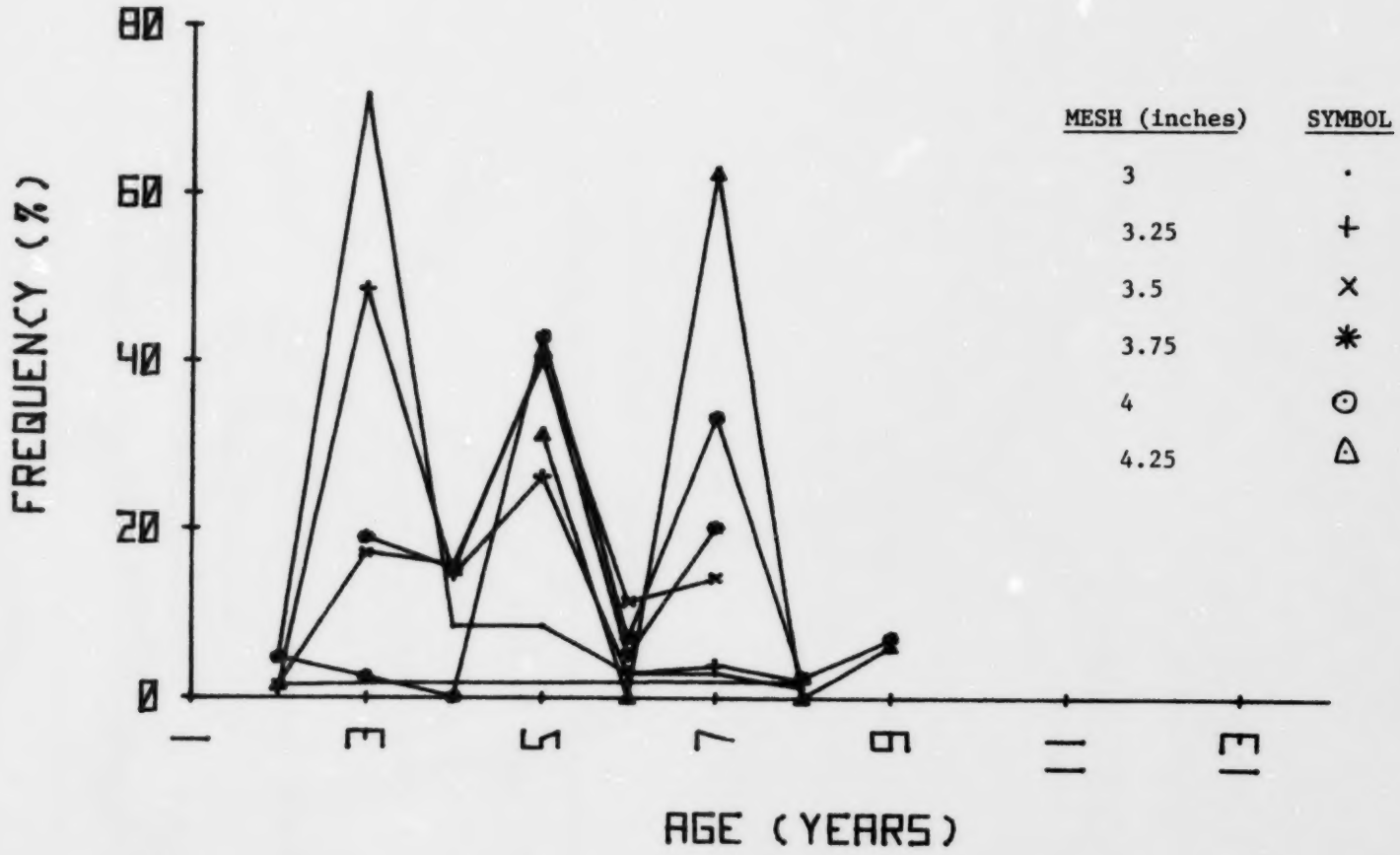


Fig. 38. Effects of mesh size on age frequency distributions of south basin walleyes.

5 and 7 year old walleyes. Conversely, age distributions of walleyes caught in the north basin were unimodal. Smaller (3-3.25 inch) (76.2-82.55 mm) meshes caught predominantly 4-6 year old walleyes while larger meshes (3.5-4.25 inch) (88.9-107.95 mm) captured 5-7 year old walleyes (Fig. 39).

Three and six year old saugers dominated the age distribution of saugers caught in all experimental meshes in the south basin while 5-7 year old saugers were predominant in all meshes set in the north basin. One and two year old saugers were captured by most meshes in the south basin while they were rare or absent from most meshes in the north basin. Eight and nine year old saugers were captured more frequently in the north basin (Figs. 40, 41).

Age compositions, catch curves and mortality rates

The age composition of experimentally netted northern walleyes was unimodal while that of southern walleyes was plurimodal (Fig. 42). The mean weighted age of northern walleyes, 5.62 years, was 1.28 years older than that of southern walleyes, 4.34 years. Relatively weak contributions of 4 and 6 year old walleyes to the south basin age composition resulted in an irregularly shaped catch curve (Fig. 43) which in turn precluded the use of 3-6 year old age frequencies in estimating mortality rates (Table 19). Robson-Chapman and regression estimates of north basin walleye mortality were extremely similar and were substantially lower than their southern counterparts (Table 19).

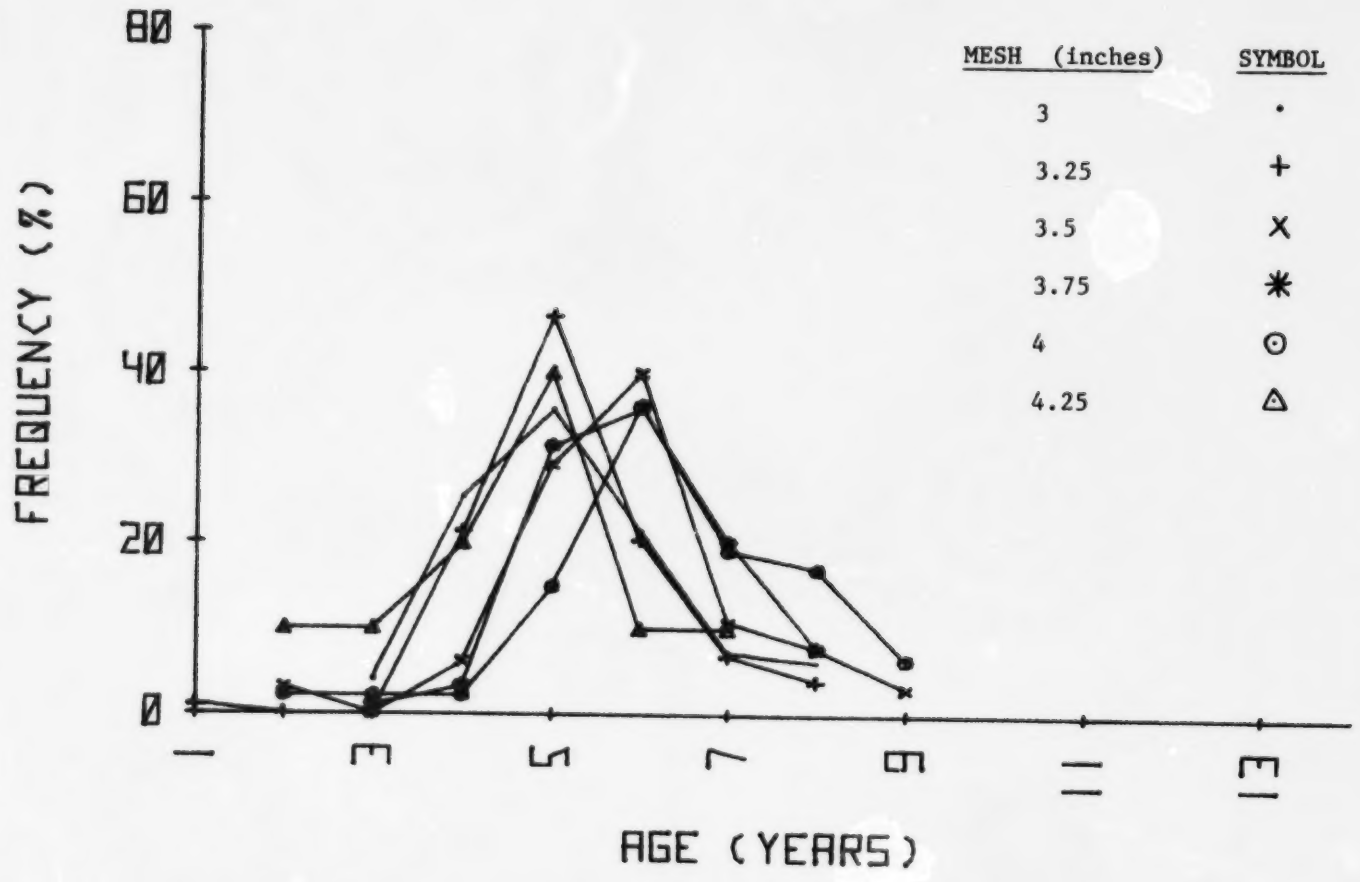


Fig. 39. Effects of mesh size on age frequency distributions of north basin walleyes.

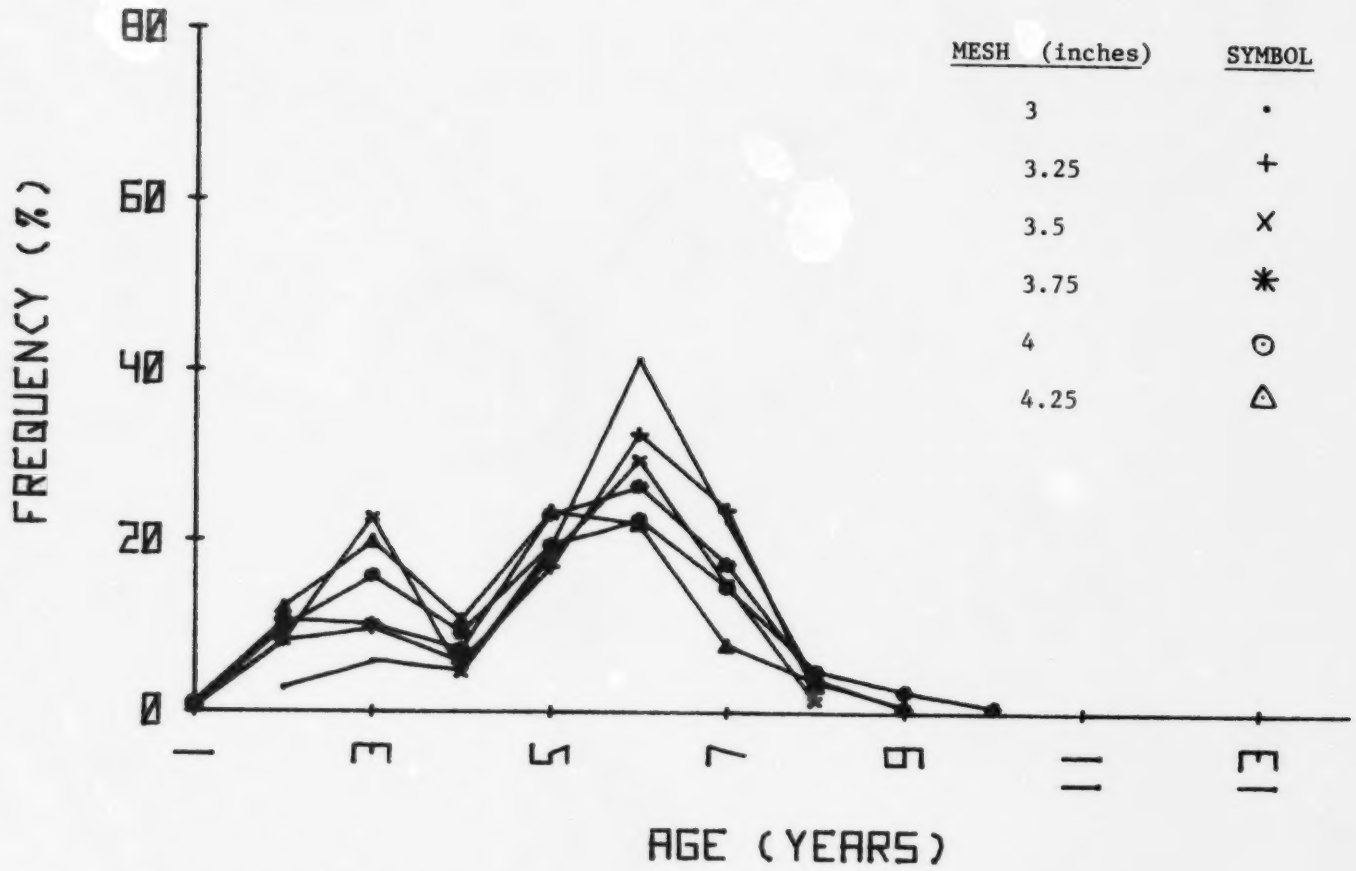


Fig. 40. Effects of mesh size on age frequency distributions of south basin saugers.

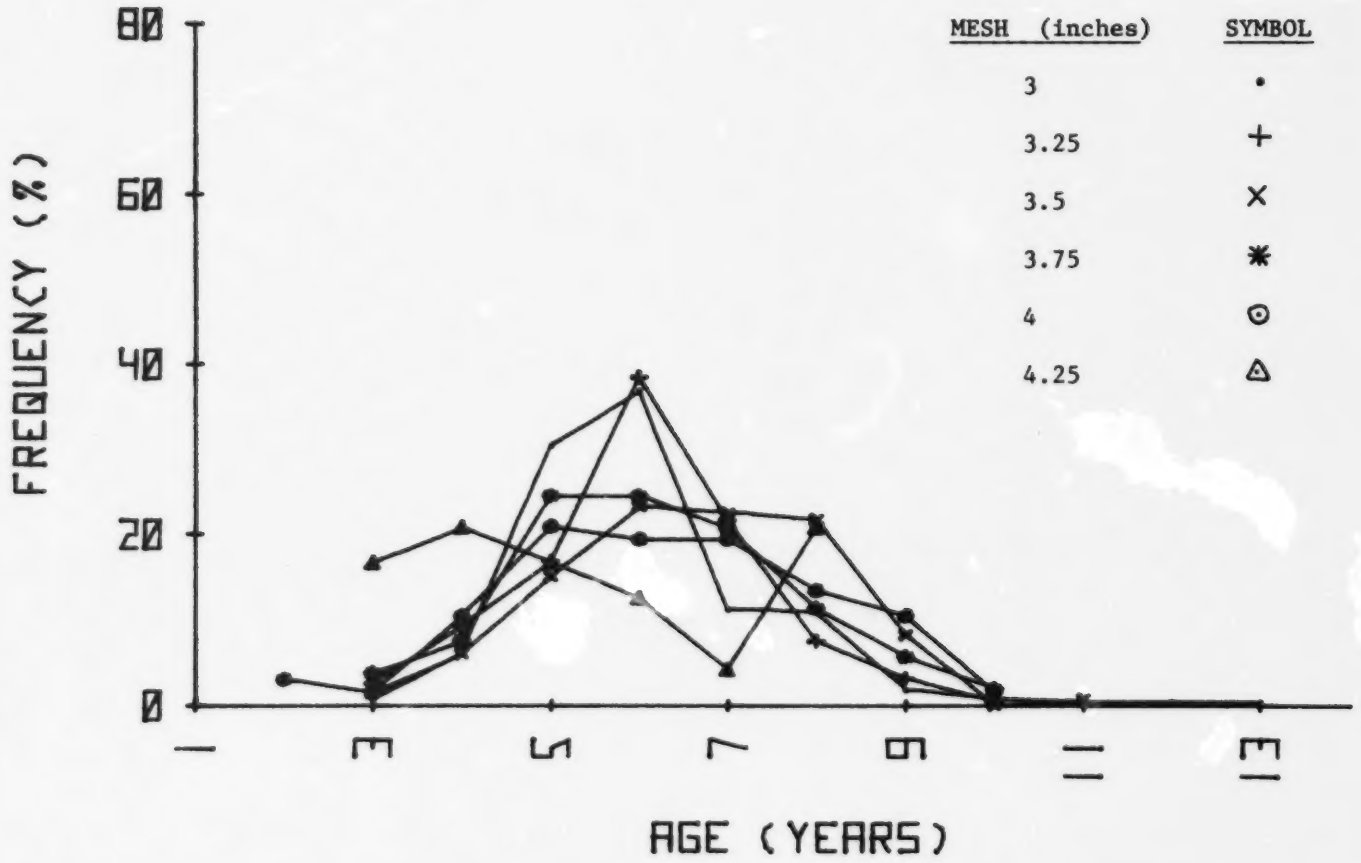


Fig. 41. Effects of mesh size on age frequency distributions of north basin saugers.

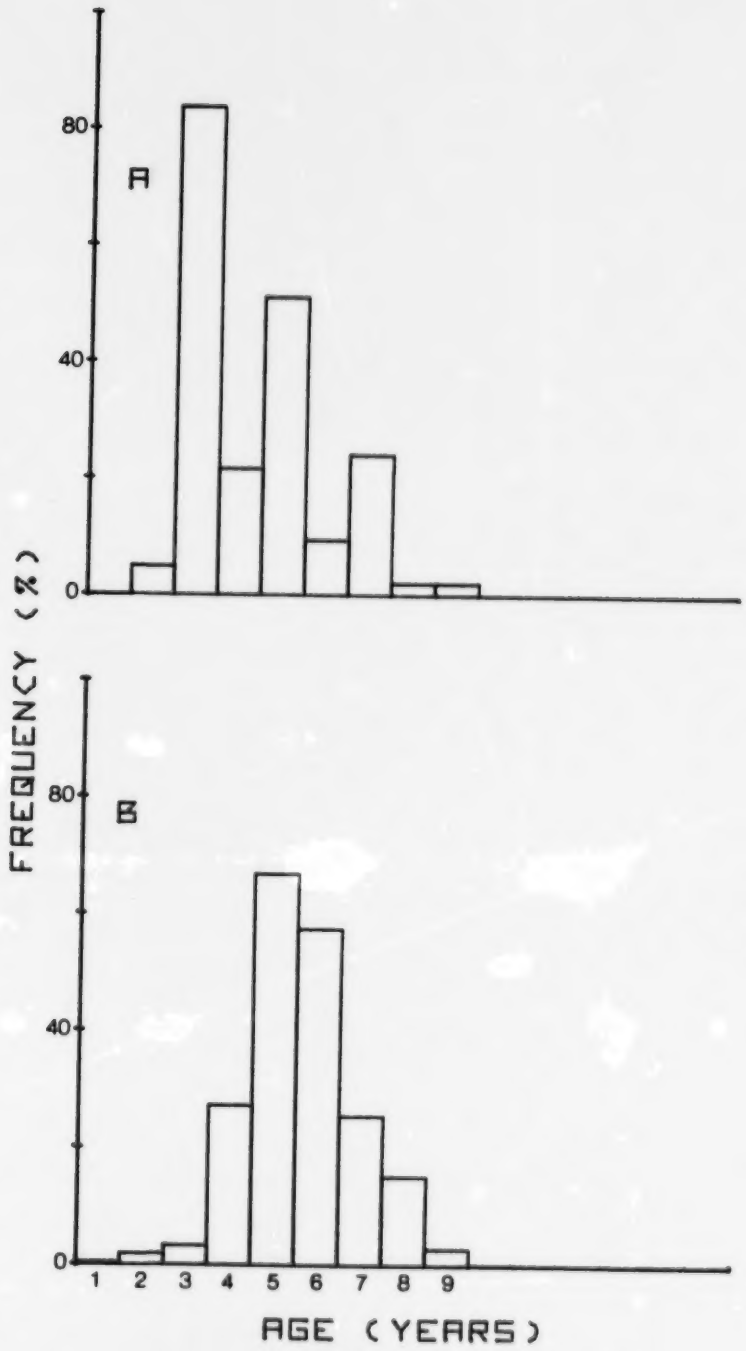


Fig. 42. Experimental age compositions of walleyes from the south (A) and north (B) basins of Lake Winnipeg, 1981.

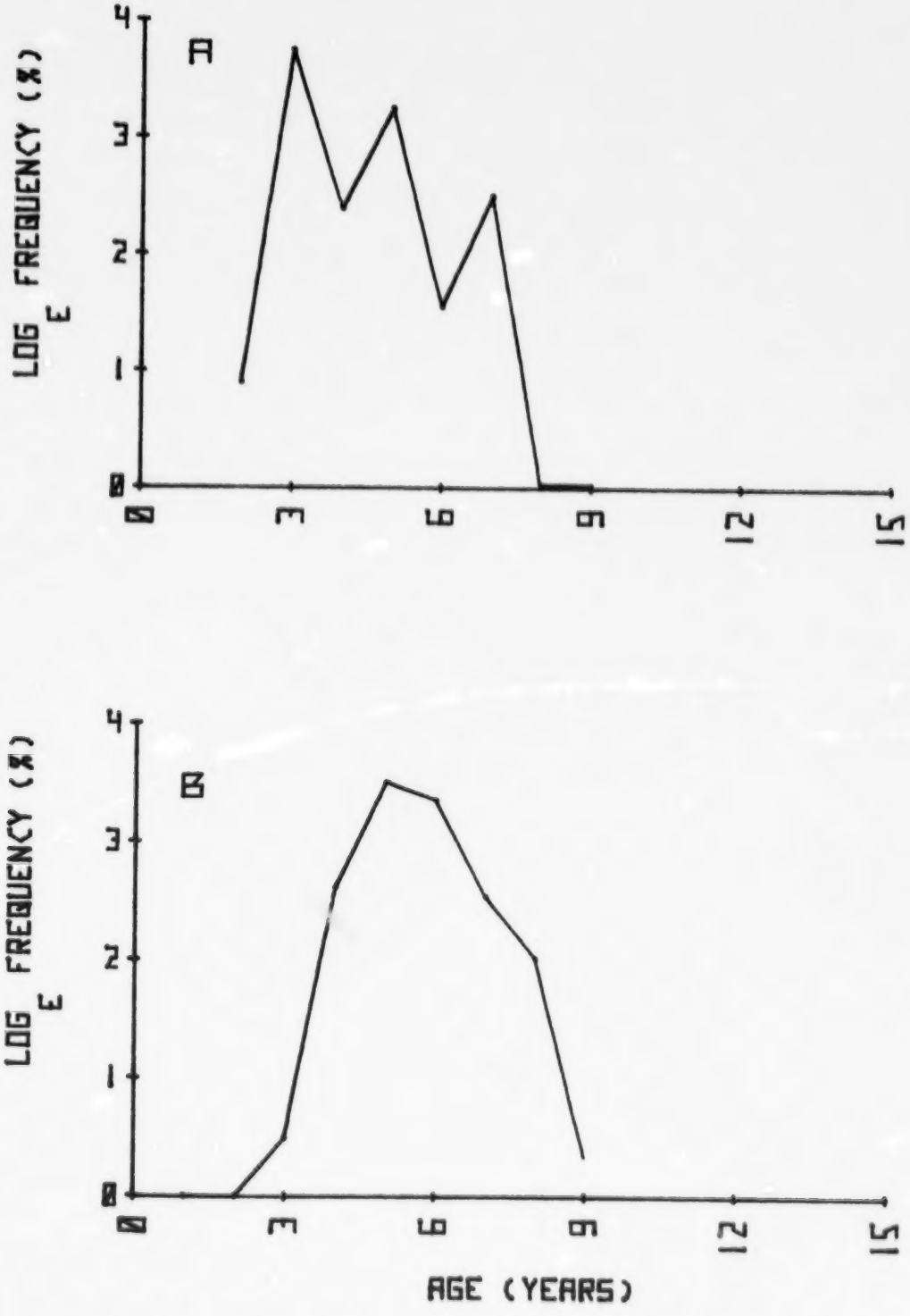


Fig. 43. Catch curves of experimentally caught walleyes from the southern (A) and northern (B) basins of Lake Winnipeg, 1981.

Table 19. Mortality and survival rates of walleyes, saugers and whitefish caught in experimental nets.

Species	Area	Robson-Chapman			Regression		
		Z	A	S ± 2 S.E.	Z	A	S
Walleye	North	.928	.6046	.1739 < .3954 < .6169	.956	.6156	.3844
	South (ages 7-9)	1.659	.8096	-.1920 < .1904 < .5728	1.232	.7083	.2917
Sauger	North	.853	.5738	.1673 < .4262 < .6852	.978	.6239	.3761
	South	1.846	.8421	-.1264 < .1579 < .4421	1.894	.8495	.1505
Whitefish	North	1.169	.6894	.1021 < .3106 < .5190	1.455	.7666	.2334

Similarly, the age composition of north basin saugers was unimodal while its southern counterpart was bimodal (Fig. 44). The mean weighted age of northern saugers, 6.094 years, was .8 years older than that of southern saugers, 5.294 years. Robson-Chapman and regression estimates of the mortality rate of saugers in each basin were similar. The survival rate of the southern sauger stock was lower than that of north basin saugers (Table 19, Fig. 45).

The mean weighted age of the whitefish stock, 4.64 years, decreased by .9 years since 1980. Four to six year old whitefish continue to dominate the age composition (Fig. 46).

Commercial catch analysis

Mortality rates of saugers caught during both the summer and fall fisheries were lower in the north basin than in the south basin (Table 20). Similar temporal trends occurred in sauger catches at Gimli and Selkirk during the summer fishery. Both areas relied heavily on 3 and 4 year old saugers. In early June, 2 year old fish were not present in the Selkirk catches. By late June, 2 year old saugers had been recruited to the fishermens nets and were totally depleted by early July (Fig. 47). Sauger catches at Matheson Island were comprised mainly of 4 and 5 year old fish and the catch curve was characterized by more older age classes than occurred in the south basin (Fig. 48). By September, the proportion of 6 year old saugers caught at Matheson Island had declined while 4 and 5 year old fish remained relatively strong (Fig. 49). Autumnal catches of saugers from Gimli were strongly dominated by 4 year old fish (Fig. 50). Thus the decreasing slopes of the Gimli sauger catch curves were due to a greater reliance

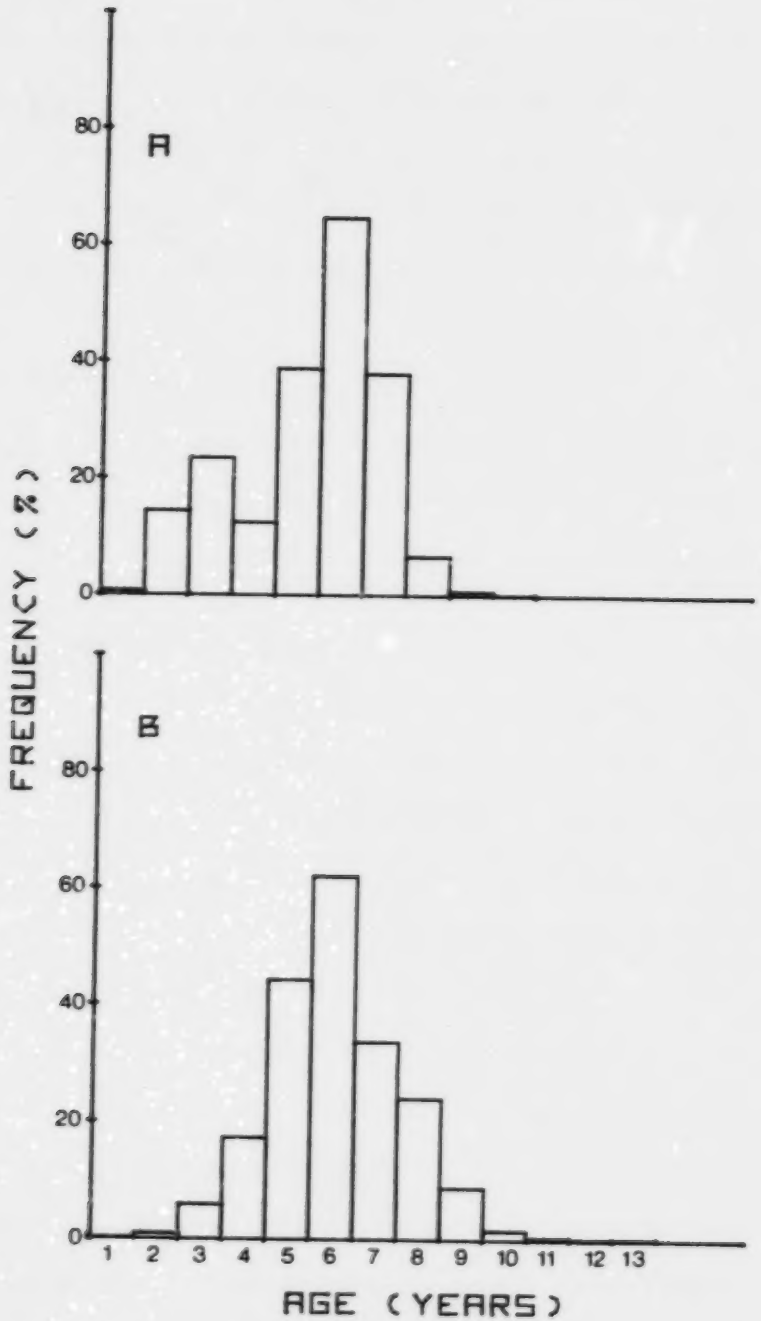


Fig. 44. Experimental age compositions of saugers from the south (A) and north (B) basins of Lake Winnipeg, 1981.

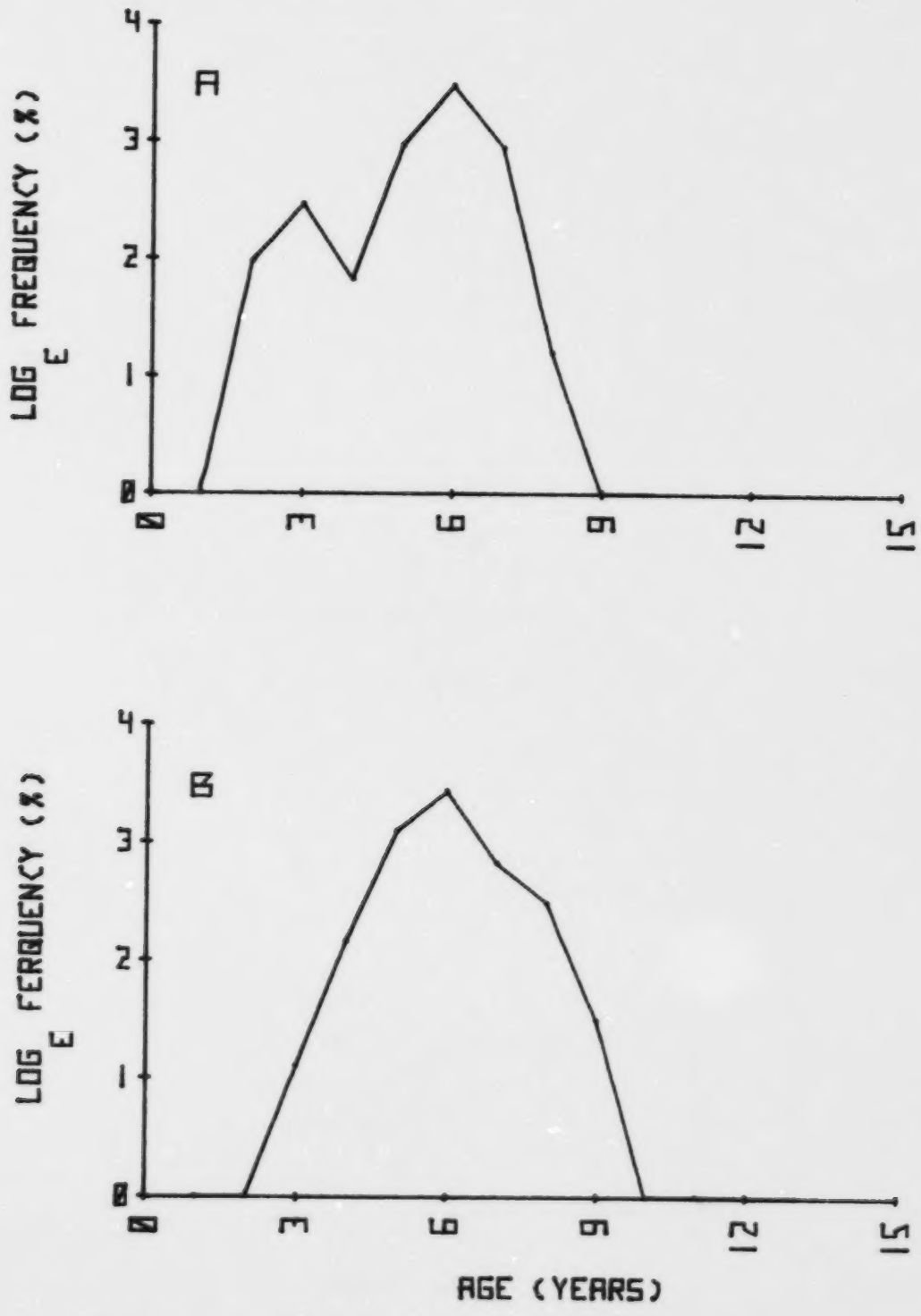


Fig. 45. Catch curves of experimentally netted saugers from the southern (A) and northern (B) basins of Lake Winnipeg, 1981.

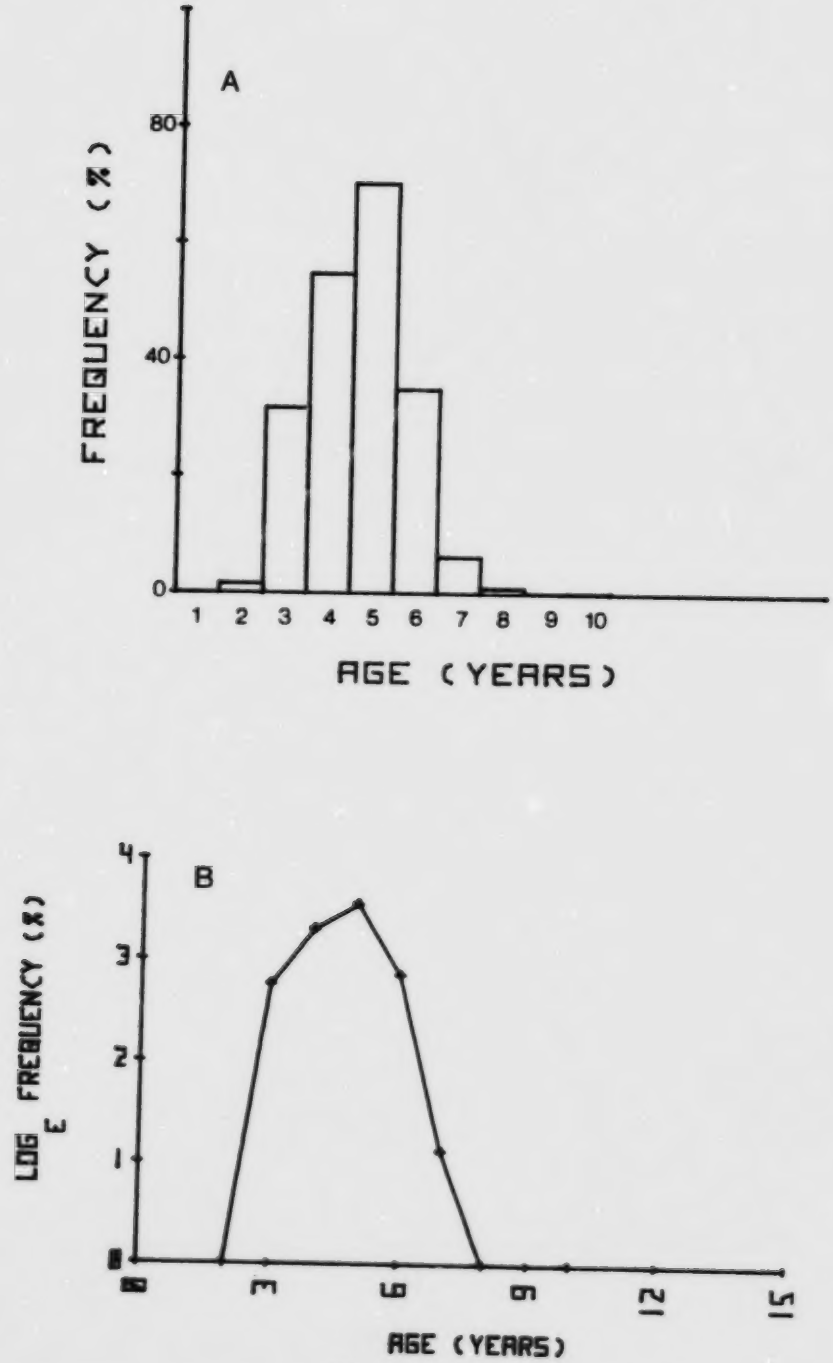


Fig. 46. Experimental age composition of whitefish (A) and resultant catch curve (B) from northern Lake Winnipeg, 1981.

Table 20. Mortality and survival rates of walleyes, saugers and whitefish caught by commercial fishermen.

Species	Area	Date	Robson-Chapman Z	Robson-Chapman A	Robson-Chapman S ± 2 S.E.		Regression Z	Regression A	Regression S	Mean weighted age (years)	Mean age of maturity (years)+	Abrasov's (1967) t index (years)
Walleye	Sturgeon Bay Matheson Is., Berens R.	June	2.275	.8972	-.1419	<.1028 <.3475	1.479	.7721	.2279	5.36	7.34	-1.98
	Sturgeon Bay	June 11	1.274	.7202	.0579	<.2798 <.5016	1.106	.6691	.3309	5.53	North basin	-1.81
	Matheson Is.	June 25	2.773	.9375	-.2081	<.0625 <.3331	1.003	.6332	.3668	4.59		-2.75
		Sept.18	.837	.5670	.2337	<.4330 <.6323	.881	.5856	.4144	4.85		-2.49
		Oct. 7	.907	.5964	.1645	<.4036 <.6427	.630	.4674	.5326	4.48		-2.86
	Berens R.	June 16	3.850	.9787	-.0729	<.0213 <.1154	1.077	.6594	.3406	5.95		-1.39
		Sept.25	1.059	.6532	.1351	<.3468 <.5586	1.374	.7469	.2531	5.85		-1.49
	Grand Rapids	June 6	2.818	.9403	-.1223	<.0597 <.2417	2.055	.8719	.1281	7.17		-0.17
		Aug. 18	2.024	.8679	-.1621	<.1321 <.4262	1.363	.7441	.2559	5.84		-1.50
	Gull Bay	June 5	2.651	.9294	-.0506	<.0706 <.1917	2.499	.9178	.0822	6.69		-0.65
	Big Black R.	June 11	2.135	.8818	-.1472	<.1182 <.3837	1.631	.8043	.1957	6.96		-0.38
	Gimli	June 9	1.069	.6567	-.0195	<.3433 <.7061	.805	.5529	.4471	3.58	5.28	-1.70
		Oct. 1	1.146	.6822	.0518	<.3178 <.5838	1.217	.7039	.2961	3.32		-1.96
	Selkirk	Sept.11	1.253	.7143	-.0317	<.2857 <.6032	1.320	.7329	.2671	3.24	South basin	-2.04
		Sept.29	1.005	.6338	.0062	<.3662 <.7386	.955	.6152	.3848	2.98		-2.30
		Oct. 13	.970	.6211	.0579	<.3789 <.6999	1.204	.7000	.3000	3.00		-2.28
Sauger	Matheson Is.	June 10	1.531	.7836	-.1170	<.2164 <.5497	1.297	.7266	.2734	4.91	4.26	+0.65
		Sept.28	1.833	.8400	-.2900	<.1600 <.6190	1.472	.7705	.2295	4.46	North basin	+0.20
	Gmili	June 9	2.259	.8955	-.1319	<.1045 <.3408	1.425	.7595	.2405	4.03	4.82	-0.79
		June 22	2.210	.8903	-.0477	<.1097 <.2671	*			3.70		-1.12
		Oct. 15	2.274	.8971	-.1295	<.1029 <.3354	2.013	.8664	.1336	4.08		-0.74
		Oct. 20	1.891	.8491	-.1601	<.1509 <.4619	1.510	.7791	.2209	4.11		-0.71
	Selkirk	June 8	2.054	.8718	-.2083	<.1282 <.4647	1.717	.8204	.1796	3.74	South basin	-1.08
		June 26	2.139	.8823	-.0670	<.1177 <.3025	1.738	.8241	.1759	3.49		-1.33
		July 2	2.189	.8880	-.0170	<.1120 <.2410	2.621	.9273	.0727	3.97		-0.85
Whitefish	North Basin	June	1.733	.8233	-.1070	<.1767 <.4603	1.314	.7313	.2687	5.09	5.05	+0.04
	Grand Rapids Warren's Landing George Is., Big Black R.	June	1.661	.8101	-.0583	<.1899 <.4380	1.307	.7294	.2706	5.29		+0.24
	Sturgeon Bay Matheson Is. Berens R.	June	2.237	.8932	-.2268	<.1068 <.4404	1.881	.8476	.1524	4.82	North basin	-0.23
	Grand Rapids	June 6	1.225	.7063	.1150	<.2937 <.4723	1.246	.7123	.2877	5.11		+0.06
		Aug. 18	2.251	.8947	-.1174	<.1053 <.3279	1.363	.7441	.2559	5.09		+0.04

* only 2 points on descending limb of catch curve

\+ for females from Table 6

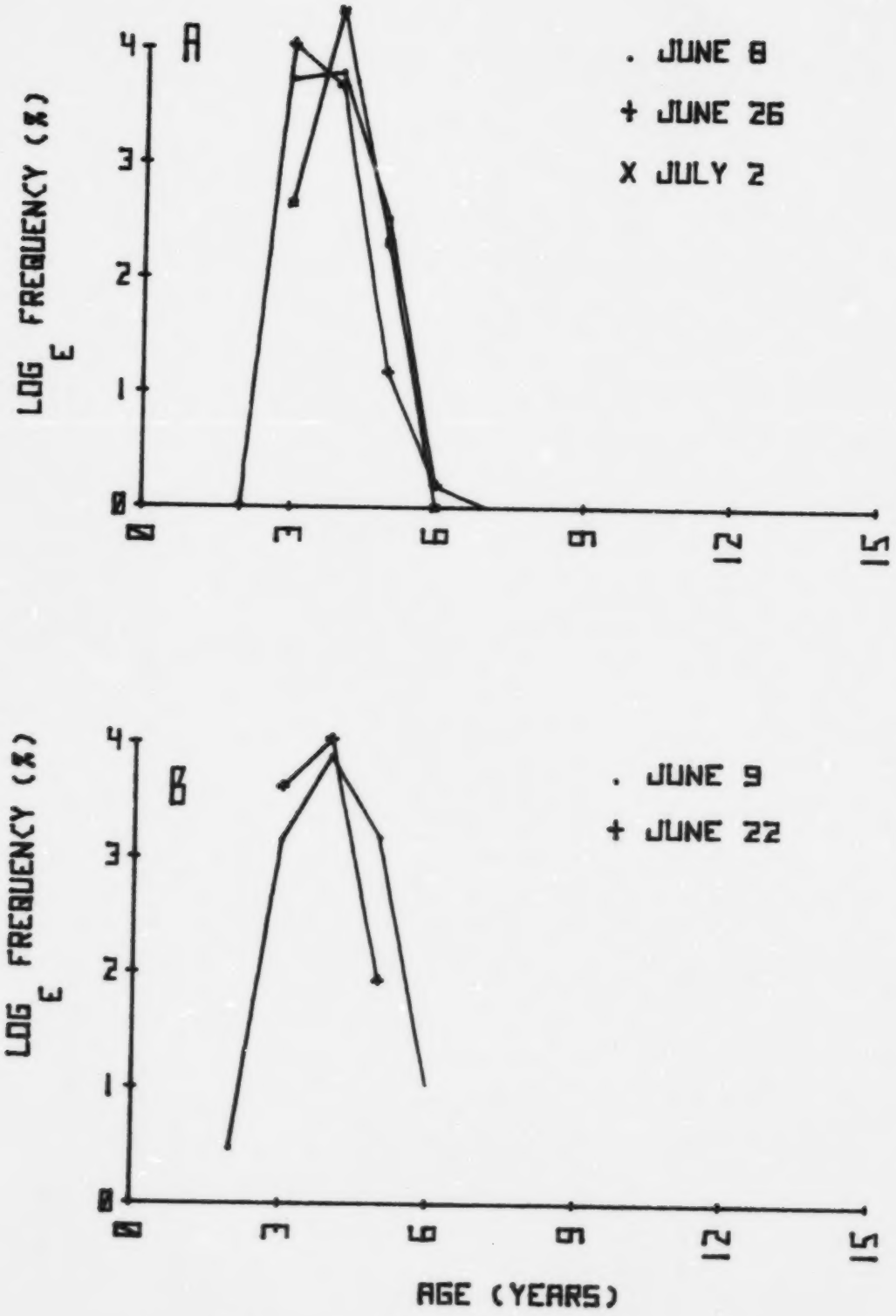


Fig. 47. Catch curves of commercially caught saugers from Selkirk (A) and Gimli (B).

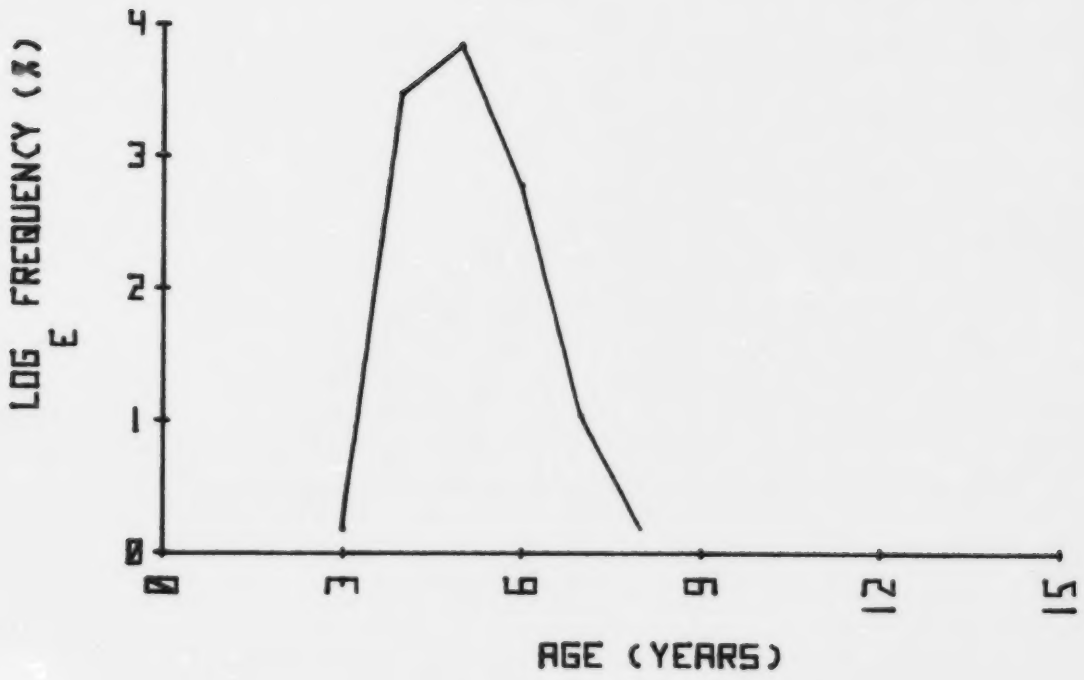


Fig. 48. Catch curve of commercially caught saugers from Matheson Island, June 10, 1981.

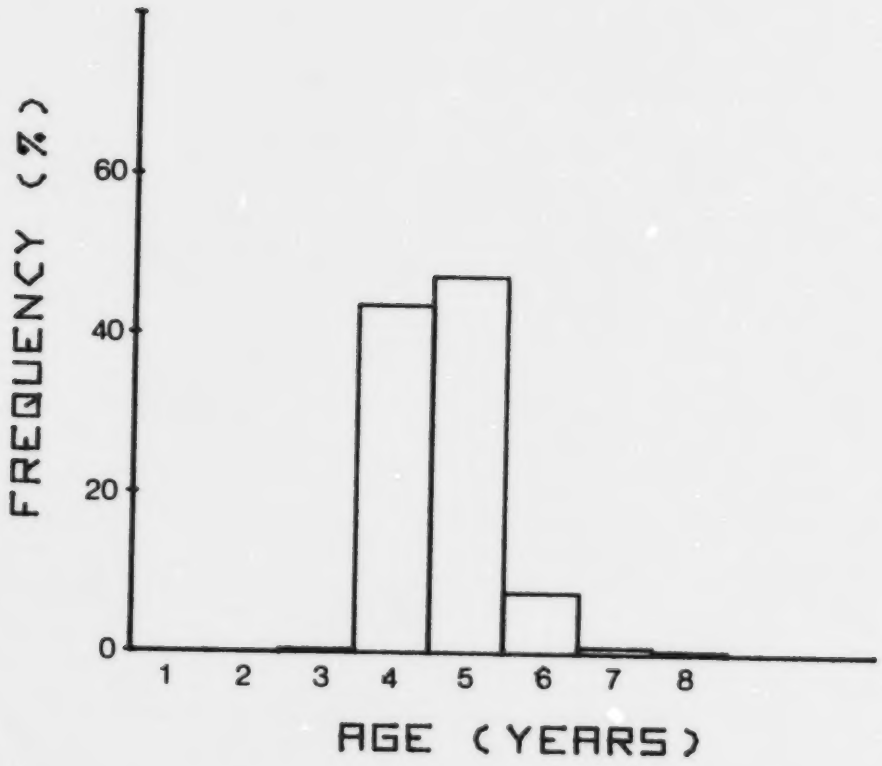


Fig. 49. Commercial age compositions of Matheson Island saugers, September 28.

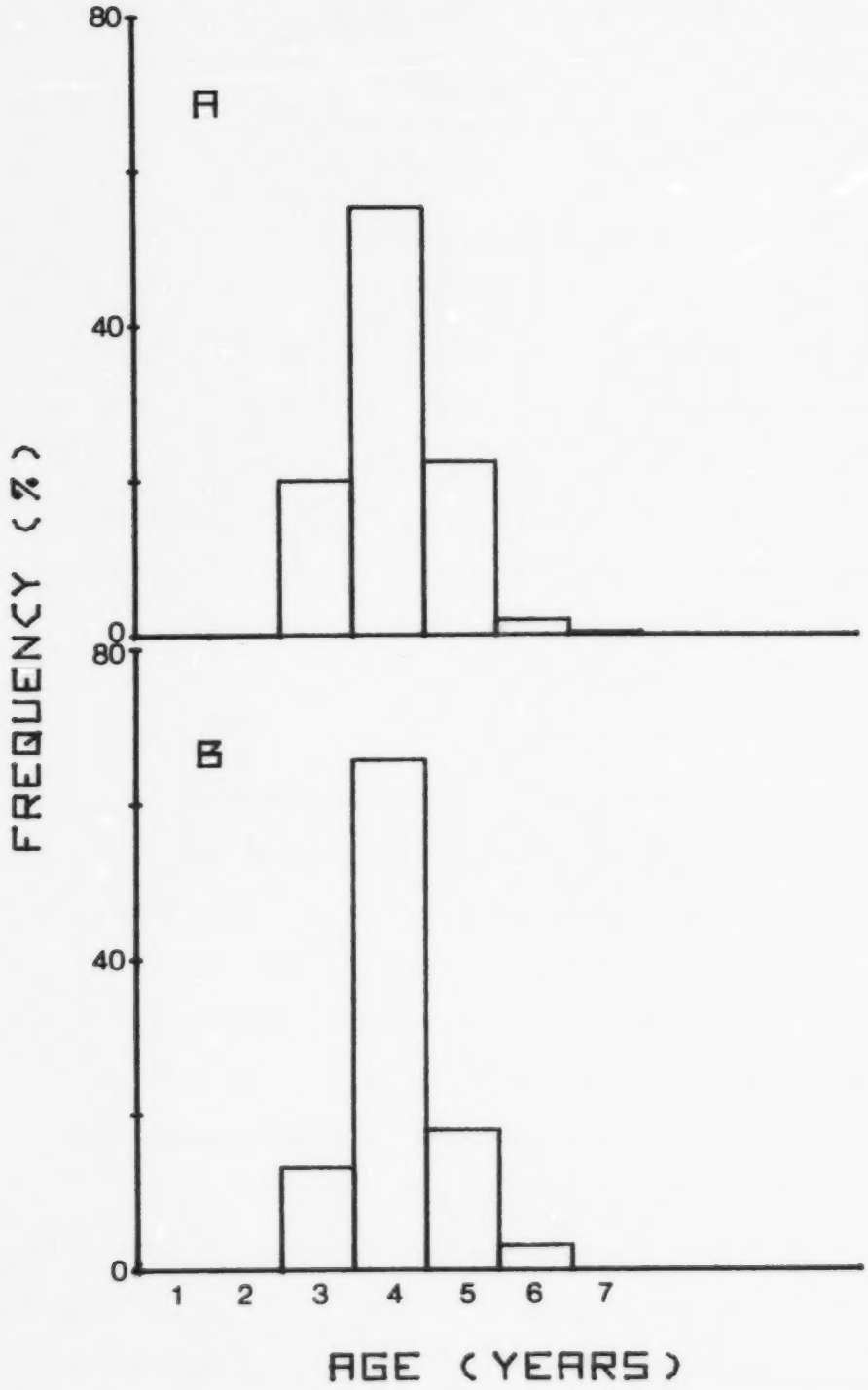


Fig. 50. Age compositions of commercially caught saugers from Gimli. A - October 15, B - October 20.

on 4 year old saugers (Fig. 51). The temporal series of Selkirk sauger catch curves illustrates not only the continuing high fishing mortality but also a high recruitment rate of 2 year old fish (Fig. 52).

The fall fishery at Grand Rapids was supported primarily by 5 and 6 year old whitefish and walleyes (Figs. 53, 54). Although the mortality rate of walleyes caught at Grand Rapids decreased slightly from summer to fall, the mean age of the commercial catch declined by 1.3 years (Table 20). The mortality rate of whitefish caught at Grand Rapids during the fall fishery was higher than it was during the summer and was similar to that of more southerly fisheries (Table 20).

Autumnal walleye fisheries at Berens River, Matheson Island, Gimli and Selkirk were all characterized by similar mortality rates (Table 20) but differences in mean ages, age ranges and dominant age groups between the northern locations (Berens River and Matheson Island) and more southerly locations (Gimli and Selkirk) were pronounced. Berens River fishermen relied almost exclusively on 5-7 year old walleyes while Gimli and Selkirk relied on 3 year old fish (Figs. 55-57). Note the strong recruitment of 2 year old walleyes and the concomitant declined of 3 year old walleyes at Selkirk (Fig. 57). The Matheson Island walleye age compositions displayed characteristics that were intermediate to those of the Berens River and Gimli-Selkirk age compositions. Relatively strong 5 and 7 year old age classes occurring early in the fall fishery diminished while 3 and 4 year old walleyes became more prevalent at the end of the fishery (Figs. 58, 59).

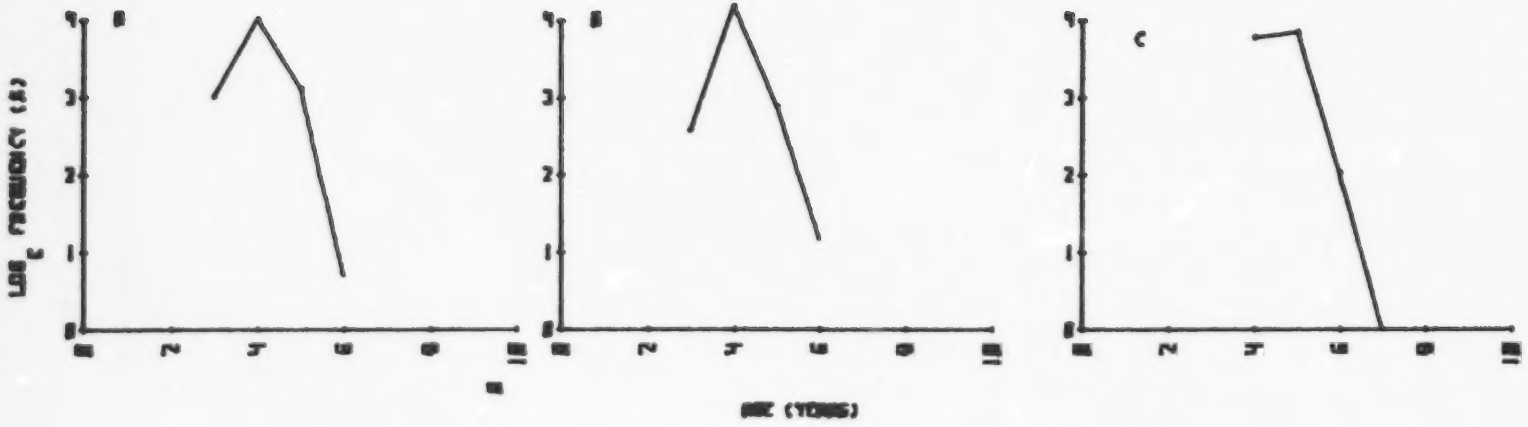


Fig. 51. Commercial catch curves of Gimli saugers sampled on October 15 (A) and October 20 (B) and Matheson Island saugers sampled on September 28 (C).

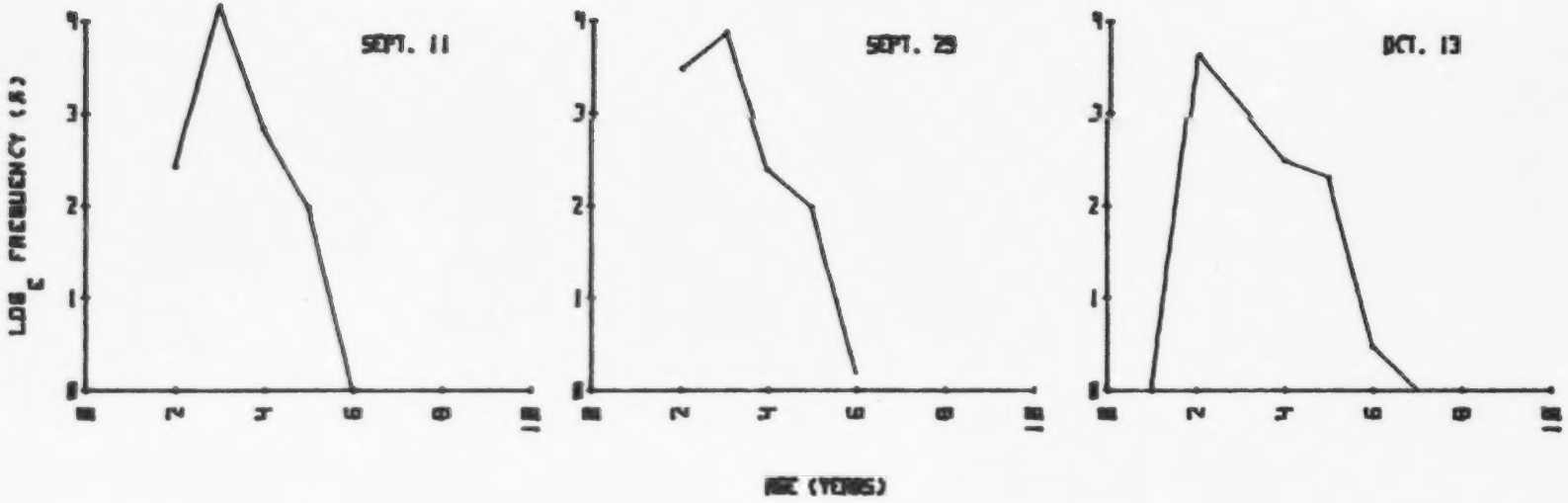


Fig. 52. Commercial catch curves of Selkirk saugers.

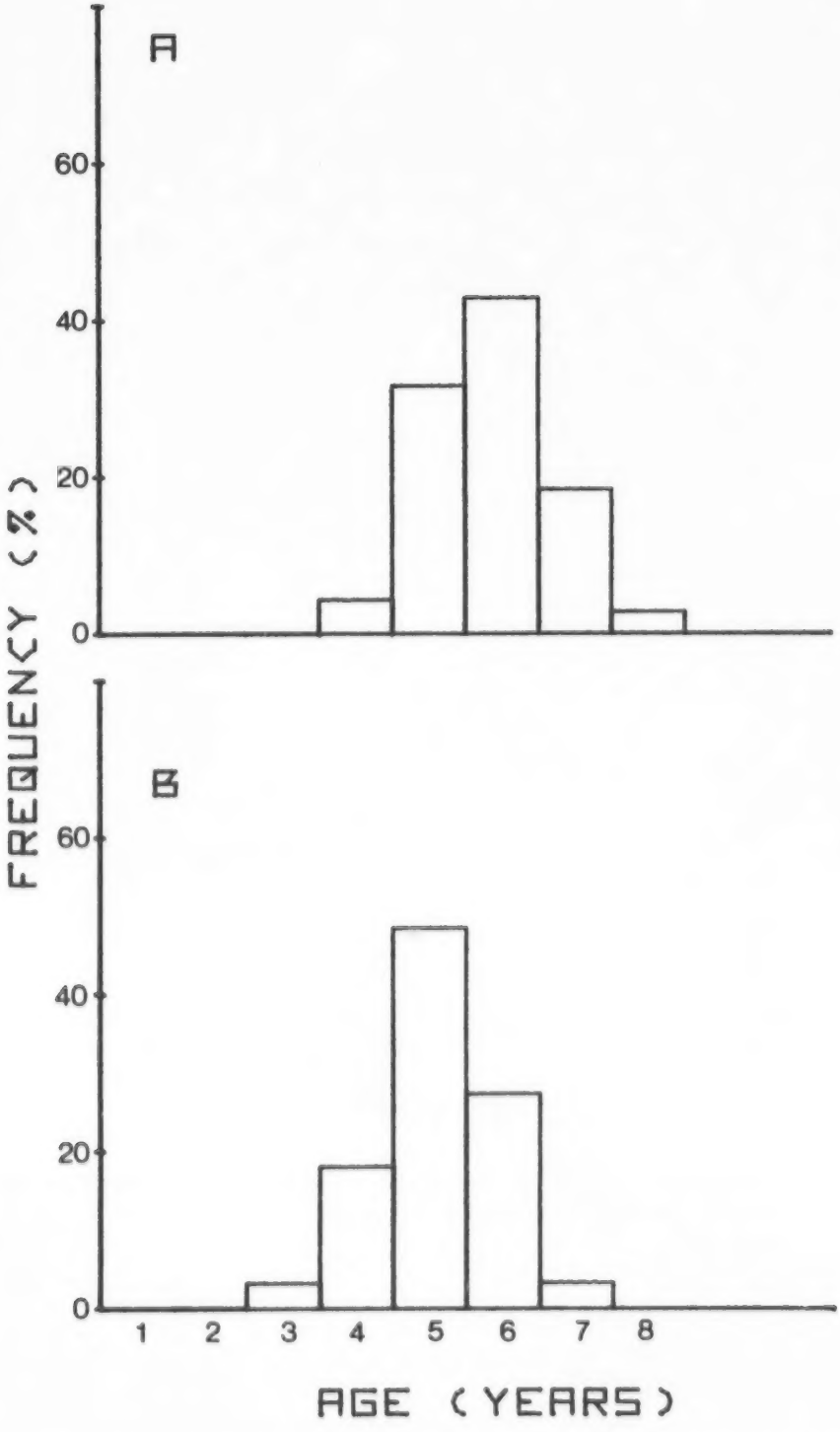


Fig. 53. Age compositions of commercially caught walleyes (A) and whitefish (B) from Grand Rapids.

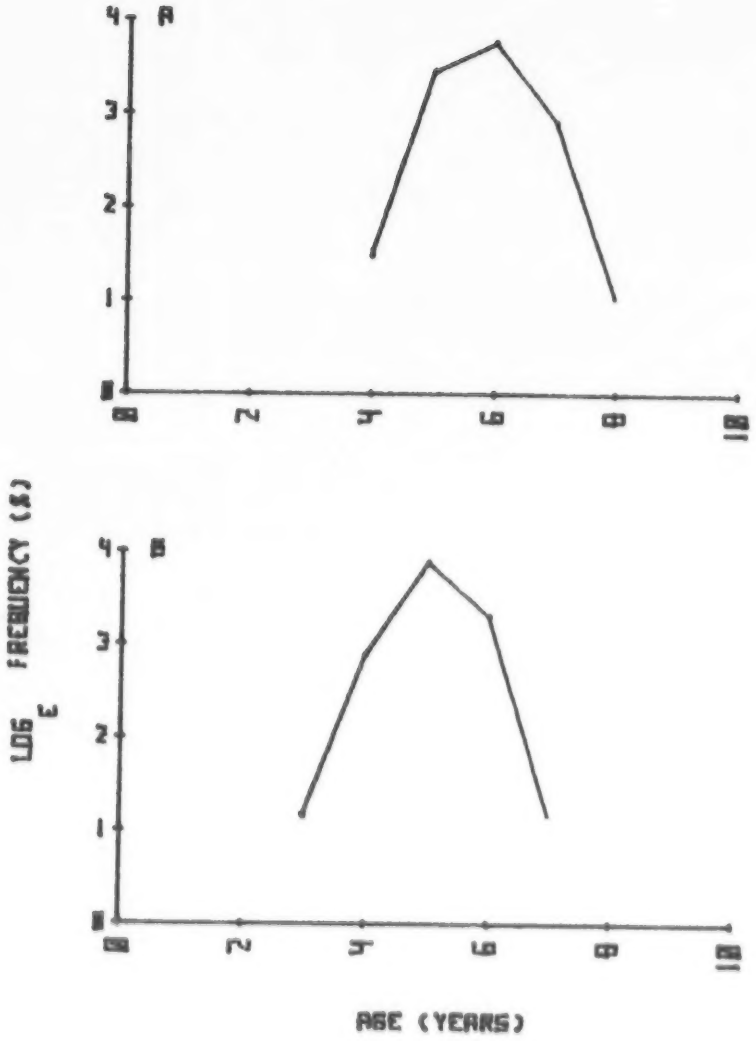


Fig. 54. Commercial catch curves of Grand Rapids walleyes (A) and whitefish (B) sampled on August 18.

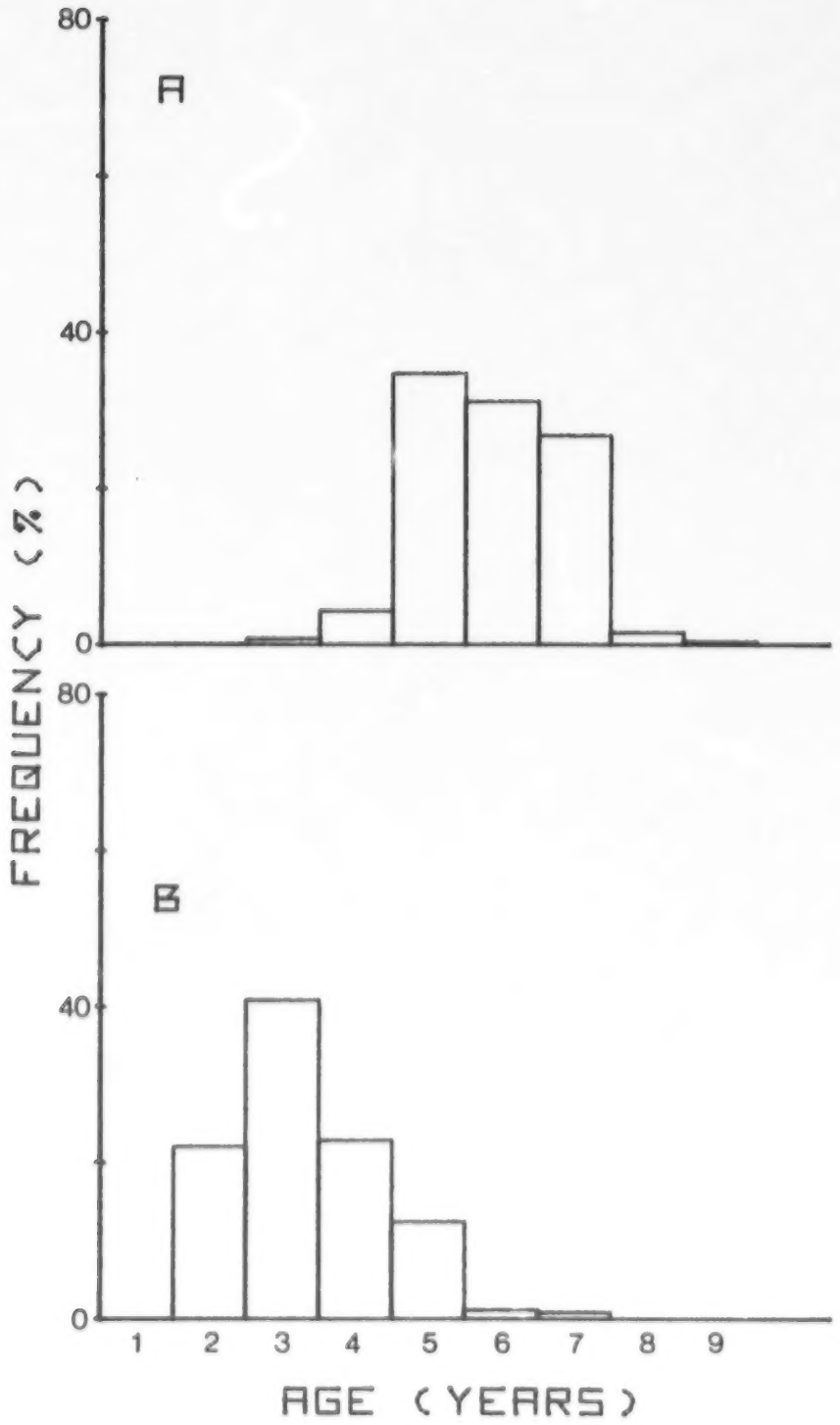


Fig. 55. Age compositions of commercially caught walleyes from Berens River, September 23 (A) and Gimli, October 1 (B).

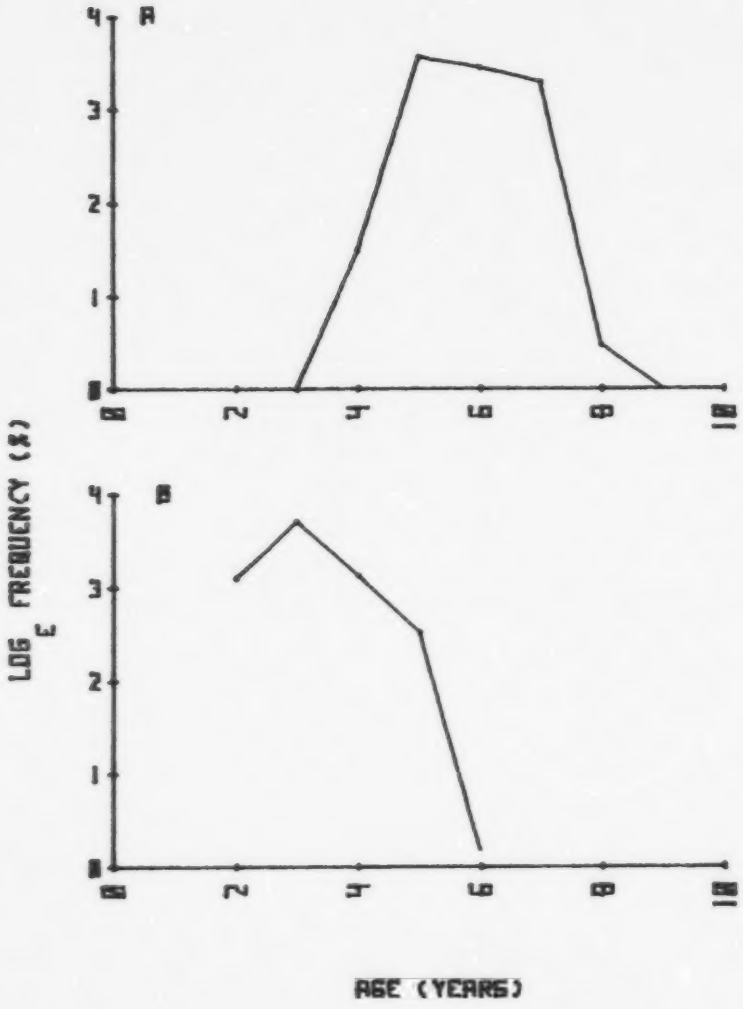


Fig. 56. Commercial catch curves of walleyes from Berens River (A) and Gimli (B).

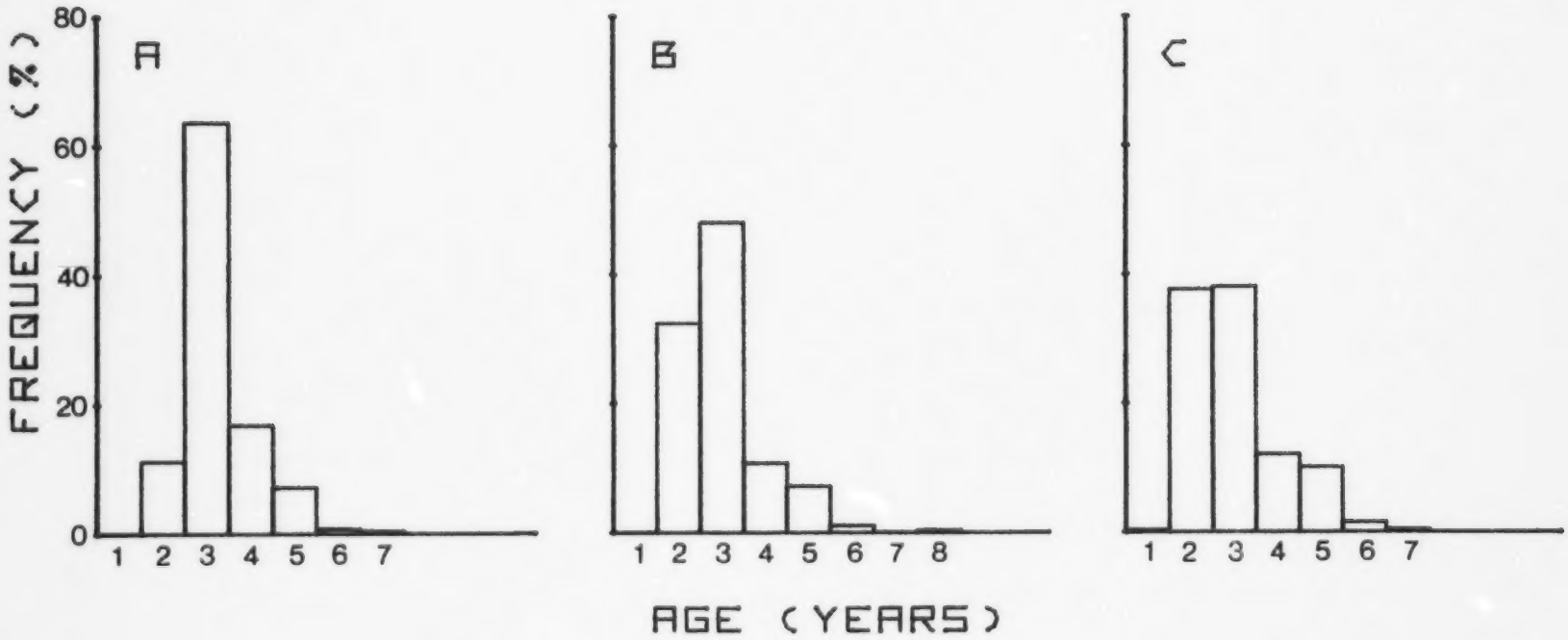


Fig. 57. Age compositions of commercially caught walleyes from Selkirk sampled on September 11 (A), September 29 (B) and October 13 (C).

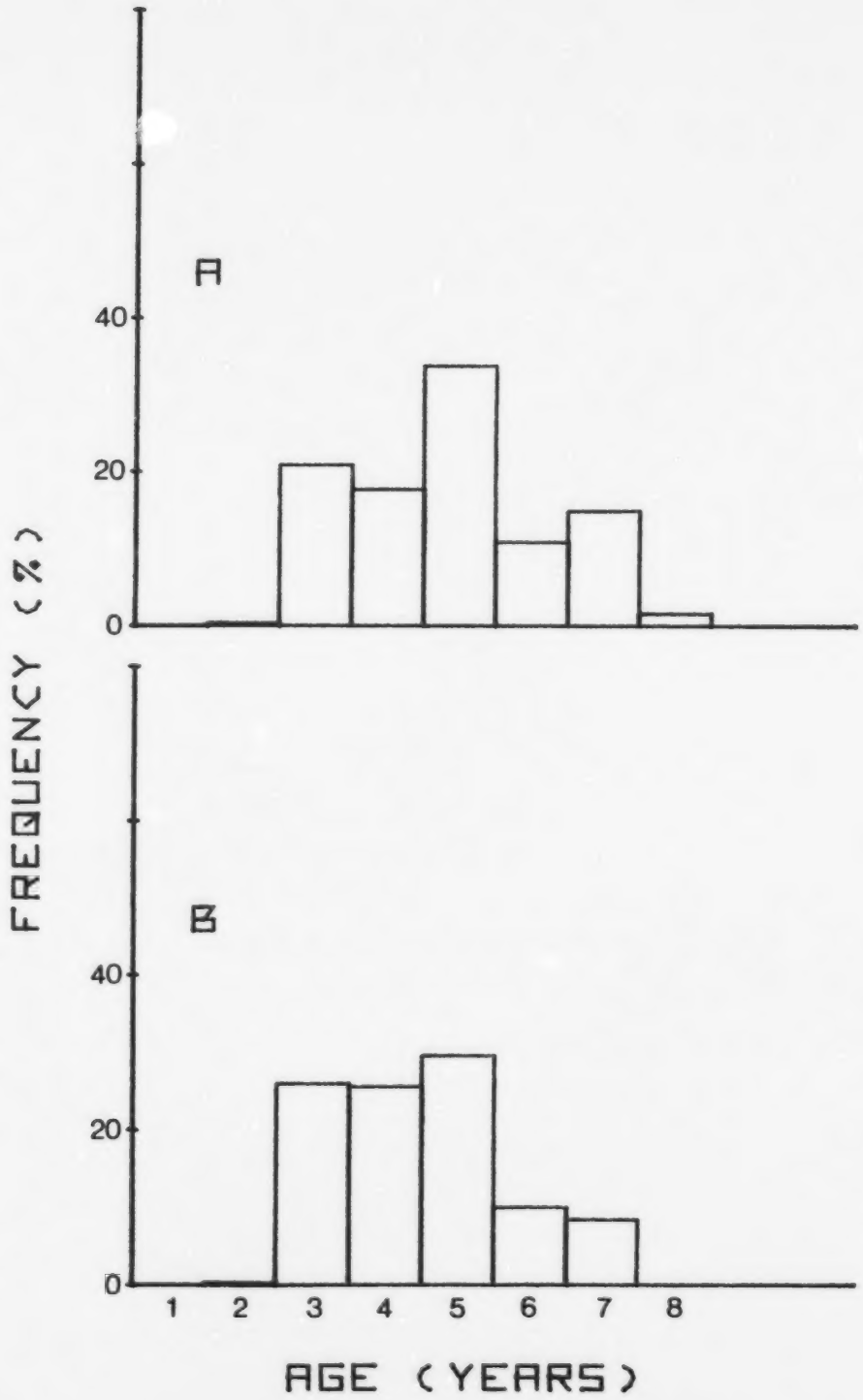


Fig. 58. Age compositions of commercially caught walleyes from Matheson Island sampled on September 18 (A) and October 7 (B).

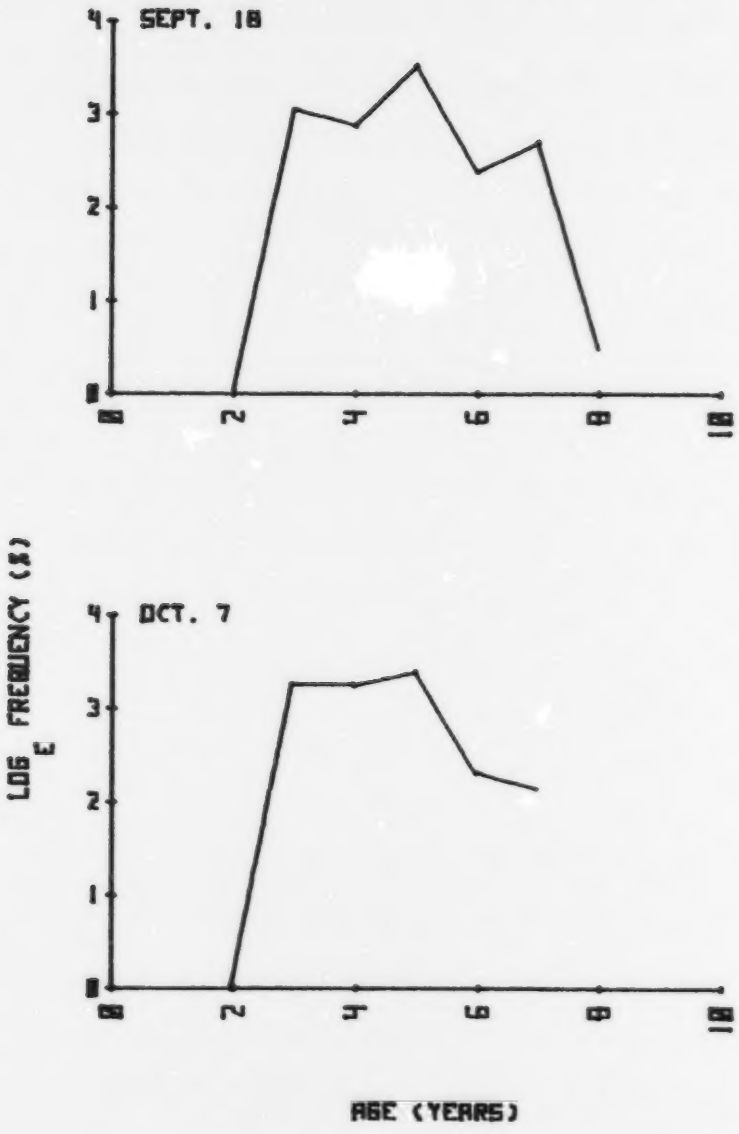


Fig. 59. Commercial catch curves of walleyes from Matheson Island.

In general, irregularly shaped catch curves of south basin walleyes produced deceiving estimates of mortality that were lower than those of more northerly fisheries (Table 20). Mean ages of commercially caught north basin walleyes were substantially higher than those of southern walleye catches. Abrasov's (1967) t index for walleyes was more negative in the south basin than in the north basin in spite of the fact that southern walleyes matured two years earlier than northern walleyes (Table 20).

South basin fishermen exploited younger saugers at a higher rate than did Matheson Island fishermen (Table 20).

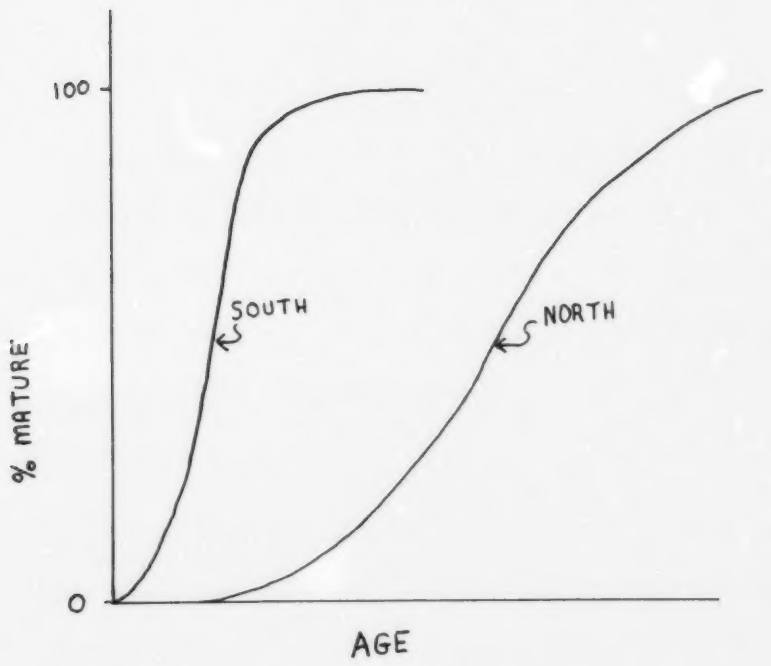
Whitefish mortality rates were higher in the more southerly regions of the north basin. Fishermen at Matheson Island, Berens River and Sturgeon Bay exploited more young and immature whitefish than northern fishermen (Table 20).

DISCUSSION

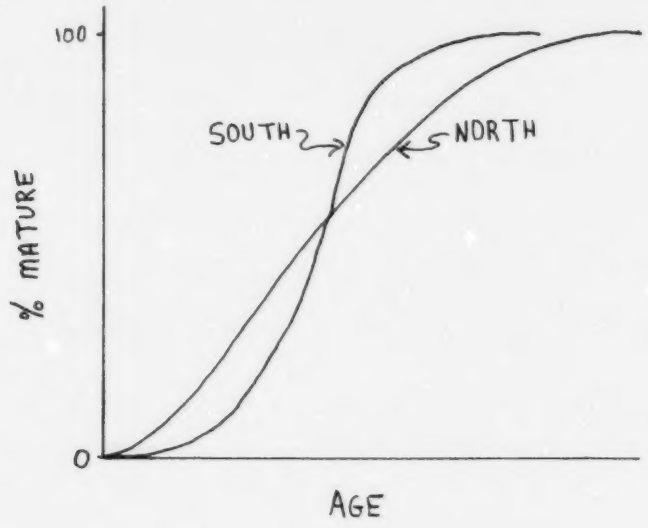
Maturity regimes

The use of covariance analysis in comparing maturity ogives or growth curves of fish stocks from the northern and southern basins of Lake Winnipeg sometimes indicates a significant difference between rates but not between elevations and vice versa. Snedecor and Cochran (1967) maintain that the most convenient approach to comparing two regression lines is to compare the residual variances first, then the slopes and lastly the elevations. They state that the final question about the elevations of the population regression lines usually has little meaning unless the slopes are not significantly different. A more recent school of thought maintains that covariance analysis is more robust

that implied by Snedecor and Cochran and that it may be used not only to test for equality of residual variances, slopes and elevations but to determine whether treatment means are related to the independent variable and whether treatment slopes are equal to a "common slope" (D. Scott, pers. comm.). Both the slope and elevation of the north basin walleye maturity ogive were significantly lower than those of the south basin counterpart. The difference between rates implies differences between shapes of the two ogives while the difference between treatment means implies that the south basin curve is shifted to the left of the north basin curve:



The south basin sauger maturity curve differed significantly from its northern counterpart in slope but not in elevation. This implies only a difference between shapes of the two ogives:



The above differences are substantiated by differences in the mean age of maturity between basins for the two species. Northern saugers mature at a slower rate than southern saugers. Northern walleyes not only mature at a slower rate than southern walleyes but begin maturing later than southern walleyes.

Growth regimes

Spatial and temporal changes in slopes and elevations of age-specific mean length-weight curves of saugers, walleyes and whitefish have been inconsistent since 1979 (Lysack 1980, 1981).

This is probably due to the combined effects of yearly variations in the time and place of experimental gang sets. In spite of these variations, the slopes of south basin walleye length-weight curves have been less than those of northern walleye stocks. However, age-specific mean length-weight curves are a poor indicator of any biological changes in a fish stock that may have been caused by commercial fisheries.

Short-term changes in the slopes and estimates of L_∞ values for all three species also have not been consistent since 1979. In any one year, L_∞ values of south basin stocks of walleyes and saugers are lower than those of northern stocks but within each basin, L_∞ values for a given species change erratically from year to year. Ricker (1975) warns that gill net selectivity depresses the left end of a Walford plot and that youngest age groups should be eliminated from the analysis. Such eliminations have partly improved the fit of Walford plots for Lake Winnipeg stocks during the last three years. In addition, one or more outliers have occurred at the right end of most Lake Winnipeg Walford plots. These aberrent outliers are all associated with age classes containing extremely few (< 5) fish. Also the precision of ageing these relatively older fish is questionable and has a pronounced effect on locations of points on the right end of the Walford plot. Weisberg (1980) states that if such outliers can be explained, then they can be eliminated from the data set. (He also describes a test for outliers).

During the last three years, elimination of data pairs associated with the youngest age-classes and of data pairs comprising outliers from Walford plots has increased the goodness of fit and provided estimates of L_∞ that approach observed maximum values in most cases. These L_∞ values have in turn been used in deriving von Bertalanffy curves. In general, the increase in goodness of fit and decrease in $L_{\infty\ predicted} - L_{\infty\ observed}$ associated with elimination of outliers in Walford analyses has been paralleled by an increase in correlation coefficients of von Bertalanffy growth curves. However, improvements in the fit of von Bertalanffy curves have often been accompanied by erractic changes in the t_o correction values. These become suspect when they range from 2-4 years.

Mesh size effects

The effects of the smaller (3 inch) (76.2 mm) commercial mesh size allowed in the south basin fisheries is illustrated by the distribution of sauger and walleye biomass over the range of mesh sizes comprising the experimental gangs. The experimental gangs set in the north basin of Lake Winnipeg continue to catch more biomass net^{-1} than they catch in the south basin in spite of the fact that southern stocks of walleyes and saugers are growing and maturing at faster rates. This is due to continuing harvests of predominately immature fish by southern fishermen. Southern basin stocks have responded to overexploitation by increasing their growth rate to its biological maximum for this climate. Mean age-specific sizes of Lake Winnipeg walleyes are

as high or higher than those of more southerly lakes (Anthony and Jorgensen 1977, Smith 1977, Kempinger and Carline 1977, Hurley and Christie 1977). Higher biomass net^{-1} values for north basin walleyes and saugers represent the fraction of stocks that have not been recruited to the larger (4.25 inch) (107.95 mm) minimum commercial mesh size permitted in the north basin of Lake Winnipeg. These northern stocks have responded to exploitation to a lesser degree since they grow and mature slower than south basin stocks. This may also be partly a function of the availability of energy and nutrients in the north basin. Colby and Nepszy (1981) demonstrated that the degree to which walleye stocks can compensate for increasing fishing effort by increasing growth and maturity rates is a function of energy and nutrient availability.

Age compositions and mortality rates

During the last three years of the stock assessment program on Lake Winnipeg, it has become increasingly evident that changes in mortality rates of north and south basin stocks are not comprehensive until they are examined in the context of the age structures of the stocks in question. For example, the instantaneous mortality rate of Grand Rapids walleye decreased between June and August, 1981 but the mean age of the catch decreased from 7.17 to 5.84 years (Table 20). Weak contributions of 4 and 6 year old walleyes to both experimental and commercial

age compositions of south basin walleyes created irregularly shapes catch curves which, in turn, produced deceivingly low estimates of mortality rates. South basin fishermen relied heavily on 3 year old walleyes during both summer and fall fisheries while north basin fishermen caught walleyes that were 4.5 - 7 years old. The extremely high recruitment rate of 3 year old walleyes and saugers to south basin commercial nets was reflected by sharply ascending limbs of catch curves (Figs. 47, 59). Colby and Nepszy (1981) reviewed responses of several overexploited walleye populations from Ontario and constructed a curve giving critical mean ages that walleye catches can be reduced without collapsing stocks as a function of available energy. The mean ages of all southern Lake Winnipeg commercial walleye catches and some of the north Lake Winnipeg catches fall below the critical line.

Erratic changes in quantified measurements of growth, maturity, mortality and biomass net^{-1} of Lake Winnipeg's walleye and sauger stocks during the last three years are partly a function of sampling variability but it is hypothesized that variations in cohort strengths and migrations of fish between the two major lake basins also contribute to these erratic changes. Before any analysis of cohort biomass growth and decay can be undertaken, we will require at least two to three more annual data sets collected in a standardized fashion. Recent increases in the numbers of new licenses issued to Lake Winnipeg fishermen are a new source of increasing fishing effort in all areas of the lake. Along with obvious increases in

mesh sizes required to increase catches in the south basin, we require limitations on entry of more individuals into an already stressed fishery.

ACKNOWLEDGMENTS

K. Campbell, K. Kristofferson, A. Desrosiers, D. MacDonald and B. Govereau performed all the field work. H. Mether ıgham and the fish aging staff determined ages of all sampled fish. J. O'Connor provided editorial advice. B. Bean typed the report. Sincere appreciation is extended to all participants.

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